NOTICE

All drawings located at the end of the document.

RMRS Rocky Mountain Remediation Services, L.L.C.
. . . protecting the environment

Document No: RF/RMRS-98-215
Revision No 2
Date January, 1999

SAFETY ANALYSIS
FOR
INDIVIDUAL HAZARDOUS SUBSTANCE SITE (IHSS) 108
TRENCH 1 (T-1) SOURCE REMOVAL PROJECT

RMRS Nuclear Safety
Rocky Flats Environmental Technology Site

RMRS ORC Review: Meeting 98-016
Date: February 25, 1998

REVIEWED FOR CLASSIFICATION/UCNI
By: UNU
Date: 2/11/99

ROCKY MOUNTAIN REMEDIATION SERVICES
NUCLEAR SAFETY APPROVAL AND DISTRIBUTION

Title: **SAFETY ANALYSIS FOR INDIVIDUAL HAZARDOUS SUBSTANCE SITE (IHSS) 108 TRENCH 1 (T-1) SOURCE REMOVAL PROJECT**	**Report No.** **RF/RMRS-98-215** **Effective Date:** March, 1998
Author: John S. Kirar	**Revision No.** 2
Performing Organization: RMRS Nuclear Safety	**Revision Date:** January, 1999
Approval: D~ Swanson Don R. Swanson, Manager, RMRS Nuclear Safety	**Copy No.**

DISTRIBUTION:

Original: RMRS Document Control Records, Building 116

Copies:
- R. L. Griffis
- J. S. Kirar
- D. R. Swanson
- S. Walker-Lembke

Author:
John S. Kirar
John S. Kirar, RMRS Nuclear Safety, Safety Analyst, ESSCO

Concurrence:
Robert L. Griffis
Robert L. Griffis, RMRS T-1 Project Manager

Reviewer:
Vern L. Peterson
Vern L. Peterson, RMRS Nuclear Safety

Concurrence:
Steve K. Crowe, K-H Division Manager, Engineering and Integration

SUMMARY

This safety analysis addresses the activities associated with the excavation and subsequent segregation and inerting of potentially pyrophoric depleted uranium chips/turnings at Trench 1 (T-1), Individual Hazardous Substance Site (IHSS) 108. As a contingency, if sufficient Volatile Organic Compound (VOC)-contaminated soils and debris are present to justify the expense, a low-temperature Thermal Desorption Unit (TDU) will be used to remove the VOCs from the contaminated soils in a non-destructive manner. If thermal desorption is used, the TDU will be similar to that used during the Mound source removal project. The use of a TDU is not analyzed in this safety analysis.

T-1 source removal activities include (1) excavation, (2) segregation, staging, and packaging of contaminated materials and soil, (3) sampling and inerting of pyrophoric depleted uranium chips/turnings, (4) storage of contaminated materials and soil, (5) on-site transportation of inerted material, (6) backfilling the trench with soils meeting accepted putback criteria, and (7) site reclamation. The inerting of the pyrophoric depleted uranium chips/turnings will be performed by the Starmet Corporation, headquartered in Concord, Massachusetts as a subcontractor to Rocky Mountain Remediation Services (RMRS). This analysis addresses only the tasks that could result in a significant airborne release of radiological and chemical contaminants, specifically, excavation (including handling of contaminated materials and soil); staging, segregation, and packaging of materials and soil; inerting of pyrophoric depleted uranium; and on-site transportation of inerted depleted uranium. Accident scenarios that could potentially occur during storage of contaminated materials and soil, packaged in DOT/Site approved shipping containers, are judged to be bounded by the accident scenarios postulated during other project activities (i.e., excavation, staging, segregation, packaging, inerting, and on-site transportation). Contamination of the local groundwater and potential resultant effects to public receptors are not addressed in this analysis since groundwater remediation is not within the scope of this project. Routine and incidental releases of contaminants (chemical and radiological) during source removal activities at the T-1 Site are evaluated in the RMRS *Site-Specific Health and Safety Plan (HASP) for the T-1 Source Removal Project, IHSS 108* (Ref. 1).

Based on a review of the *Proposed Action Memorandum for the Source Removal at the T-1 Site, IHSS 108* (Ref. 2), the *T-1 Site Source Removal Project Activity Control Envelope Process*, the site-specific HASP, and guidance set forth in DOE-STD-5502-94, *Hazard Baseline Documentation,* (Ref. 3), the T-1 Site (source removal activities) is classified as radiological requiring compliance with OSHA Standards, preparation of a site-specific HASP in accordance with 29 CFR 1926.65, *Hazardous Waste Operations and Emergency Response* (Ref. 4), and preparation of an "auditable safety analysis." This safety analysis serves as the "auditable safety analysis" for the T-1 Source Removal Project.

The radiological and chemical hazards associated with the T-1 Site source removal activities present negligible off-site impacts to the public and the environment. A depleted uranium fire scenario involving 12 containers (assumed to be 55-gallon drums) of chips/turnings has been postulated as the bounding accident scenario associated with project activities. The consequence to public receptors has been determined to be *low* for this scenario based on the consequence levels presented in Table 4-4, *Radiological Accident Consequence Levels.* The

consequence to the collocated worker has been determined to be *moderate*. Other accident scenarios evaluated in this safety analysis include container spills, a single container explosion, and transportation accidents. The assumptions used in this safety analysis and the radiological dose consequences are provided in supporting calculation 97-SAE-010 (Ref. 5).

Project hazard controls that protect the collocated worker and/or the public from radiological hazards associated with the T-1 Source Removal Project are identified in Table 5-1, *T-1 Project Hazard Controls*. These controls are credited as (1) preventing occurrence of the postulated accident scenarios, (2) mitigating the consequences if an accident were to occur, and (3) identifying unexpected hazards or conditions encountered during the project.

Unanalyzed hazards and conditions or any modifications to project activities or work that fall outside the bounds of this safety analysis shall be assessed through the Unreviewed Safety Question Determination (USQD) process.

On-site occupational hazards (radiological, chemical, biological, and physical) have been identified and are evaluated in the site-specific HASP activity hazard assessment. Controls for these hazards are also documented in the HASP.

ACRONYMS

ARF	Airborne Release Fraction
ALARA	As Low As Reasonably Achievable
BH	Borehole
CFR	Code of Federal Regulations
CSS	Contaminated Soil Stockpiles
DOE	Department of Energy
DOT	Department of Transportation
DR	Damage Ratio
EM	Environmental Management
EPA	Environmental Protection Agency
HASP	Health and Safety Plan
HEPA	High Efficiency Particulate Air
IDM	Investigative Derived Material
IHSS	Individual Hazardous Substance Site
LLW	Low Level Waste
LSAI	Low Specific Activity-I
MAR	Material-at-Risk
MOI	Maximum Off-site Individual
OSHA	Occupational Safety and Health Administration
OU	Operable Unit
PA	Protected Area
PAM	Proposed Action Memorandum
PCB	Polychlorinated Biphenyls
pCi	pico-curies
PPE	Personal Protective Equipment
PSM	Process Safety Management
RADIDOSE	Radiological Dose
RCRA	Resource Conservation and Recovery Act
RF	Respirable Fraction
RFCA	Rocky Flats Cleanup Agreement
RFETS	Rocky Flats Environmental Technology Site
RFFO	Rocky Flats Field Office
RFI	RCRA Field Investigation
RFP	Rocky Flats Plant
RI	Remedial Investigation
RMP	Risk Management Programs
RMRS	Rocky Mountain Remediation Services
RQ	Reportable Quantity
RWP	Radiological Work Permit
SAE	Safety Analysis Engineering
SAR	Safety Analysis Report
SIP	Sampling and Inerting Pad
SVOC	Semivolatile Organic Compounds
T-1	Trench-1
TDU	Thermal Desorption Unit
TNT	2,4,6-trinitrotoluene
TPQ	Threshold Planning Quantity
TQ	Threshold Quantity
TSR	Technical Safety Requirement
TVOCs	Total Volatile Organic Compounds
UN	United Nations
USQD	Unreviewed Safety Question Determination
VOC	Volatile Organic Compound

SAFETY ANALYSIS INDIVIDUAL HAZARDOUS SUBSTANCE SITE (IHSS) 108 T-1 SOURCE REMOVAL PROJECT

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

1.1 Overview

The T-1 Site is located about 40 feet south of the southeast corner of the protected area (PA) fence. The trench is approximately 200 to 250 feet long, 16 to 22 feet wide, and 10 feet deep. Figure 1 shows the T-1 Site layout.

The proposed actions that will be undertaken at the T-1 Site include removing and stabilizing the potentially pyrophoric uranium (depleted) from the trench and removing and treating (if necessary) debris, contaminated soils, and other material that may be contained in the trench. The objective of the action is to remediate the risk posed to the environment and future users of the site by removing the pyrophoric uranium and other materials. The depleted uranium will be inerted preparing it for off-site shipment and subsequent treatment. The depleted uranium and associated materials excavated from the trench are expected to be Low Level Waste (LLW).

The available historic information and recent characterization data do not indicate that T-1 is a source of volatile organic compound (VOC) contamination to subsurface soil or groundwater. If extensive VOC contamination above Rocky Flats Cleanup Agreement (RFCA) (Ref. 6) Tier I action levels is encountered in the trench, these materials would be temporarily stored pending treatment by low temperature thermal desorption. Upon successful treatment, the soils will be returned to the trench as backfill.

Upon completion of the source removal, the trench will not contain depleted uranium or soils contaminated above RFCA Tier I action levels for radionuclides or VOCs. The project will be conducted in accordance with the RFCA guidelines, Federal, State and Local laws, DOE Orders, and RFETS policies and procedures.

1.2 Regulatory Drivers

DOE-EM-STD-5502-94, *Hazard Baseline Documentation* (Ref. 3), establishes uniform DOE Office of Environmental Management (EM) guidance on hazard baseline documents that identify and control radiological and non-radiological hazards for all EM facilities. The standard provides a "road map" to the safety and health hazard identification and control requirements contained in DOE Orders and provides EM guidance on the applicability and integration of these requirements. The standard includes (1) the definition of four classes of facilities (nuclear, non-nuclear, radiological, and other industrial facilities); (2) thresholds for facility hazard classification; and (3) the applicable safety and health identification, controls, and documentation. The standard requires the cognizant contractor to identify the activities, or groups of activities that logically should be grouped as a "facility" for the purpose of facility classification and safety and health documentation development. The thresholds for facility hazard classification are:

- Nuclear Facility Hazard Category 3 thresholds per DOE Order 5480.23, *Nuclear Safety Analysis Reports* (Ref. 7) and DOE-STD-1027-92, *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports* (Ref. 8),

- Reportable Quantities (RQs) per 40 CFR 302, *Designation, Reportable Quantities, and Notification* (Ref.9).
- Threshold Quantities (TQs) per 29 CFR 1910.119, *Process Safety Management (PSM)*(Ref. 10) and 40 CFR 68, *Risk Management Programs (RMP) for Chemical Accidental Release Prevention* (Ref. 11), and
- Threshold Planning Quantities (TPQs) per 40 CFR 355, *Emergency Planning and Notification* (Ref. 12).

DOE Order 5480.23 is the primary Order governing safety analysis requirements for nuclear facilities. Facilities are designated as "Nuclear Facilities" if the radiological inventory exceeds the threshold values in DOE-STD-1027-92. DOE-STD-1027-92 identifies the threshold between a Category 3 Nuclear Facility and a below Category 3 Nuclear Facility as a comparison of the total segmented inventory with the values in the standard.

The RQs in 40 CFR 302, Appendix B, *Radionuclides*, are used to establish the dividing line between radiological or non-nuclear facilities and other EM industrial facilities. The levels in 40 CFR 302 are based on the RQs in curies of material for radioactive substances. The RQs are based on the potential release of materials into the environment.

The basis for the application of the PSM Standard, 29 CFR 1910.119, and RMP Rule, 40 CFR 68, is the inventory quantity of hazardous substances that is determined by gross amounts (unadjusted by process) of hazardous materials. The PSM Standard was promulgated to prevent and mitigate the effects of major accidents at chemical facilities that can result in loss of life to workers. The RMP Rule was promulgated to prevent and mitigate the effects of accidental releases of hazardous materials that could affect public health and/or the environment. Exceeding TQs in 29 CFR 1910.119 and 40 CFR 68 triggers PSM and RMP respectively and classifies the facility as either radiological or non-nuclear. Based on the chemical inventory at the T-1 Site excavation area, the PSM Standard and RMP Rule are not invoked.

The TPQs in 40 CFR 355 are used to determine whether or not emergency planning and release notification are required based on an airborne release of any listed chemical. Exceeding TPQs in 40 CFR 355 triggers compliance with emergency planning and release notification requirements and classifies the facility as either radiological or non-nuclear.

The RQs in 40 CFR 302, Table 302.4, *List of Hazardous Substances and Reportable Quantities*, are used to establish the dividing line between non-nuclear facilities and industrial facilities. The levels in 40 CFR 302 are based on the RQs in pounds of material for hazardous substances. The RQs are based on the potential release of materials into the environment.

If none of the above thresholds are exceeded based on chemical and radiological inventories, an industrial facility classification can be assigned.

2. ACTIVITY DESCRIPTION

Major activities that will be performed as part of the T-1 Source Removal Project include:

- Excavation of soil, containers, and debris,
- Staging, segregation , and packaging of contaminated materials and soil,
- Sampling and inerting depleted uranium chips/turnings,
- Storage of contaminated materials and soil,
- On-site transportation of inerted material,
- Backfilling Trench, and
- Site Reclamation.

The activity descriptions provided in this section of the safety analysis are for information only. They provide the reader with information helpful to understanding the safety analysis in Section 4 and derivation of the hazard controls presented in Section 5. They should not be interpreted as the necessary physical and/or administrative controls credited in the safety analysis. Credited preventive and mitigative controls are provided in Table 5-1, *Project Hazard Controls*.

Excavation, segregation, and inerting activities, with the exception of transfers of waste/material to other areas, will be conducted within a temporary structure (e.g., Sprung Instant Structure) providing protection from environmental conditions (e.g., wind, rain, snow, etc.). The structure will be constructed over the entire T-1 excavation area. Design features include a Sampling and Inerting Pad (SIP) for inerting the depleted uranium and a soil stock-pile area for stock-piling soils that do not exceed the RFCA Tier I action levels. No more than one batch of excavated material (a maximum of six previously buried containers of depleted uranium chips) will be present at the SIP at any one time.

2.1 Excavation

Conventional excavation techniques will be used to remove the overburden soil, drums, debris, and contaminated soils at the T-1 site. Excavation equipment will consist of a track-mounted excavator, backhoe, and/or front-end loader. The excavator bucket will be equipped with brass or bronze teeth to minimize spark-potential while handling containers of depleted uranium that may contain a potentially explosive mixture of hydrogen and oxygen. Drums will be removed from the excavation one-at-a-time in order to minimize exposure to workers, the public, and the environment. Standard fire prevention and suppression techniques for pyrophoric metals will be utilized (Ref. 13). Extinguishing agents for the potentially pyrophoric depleted uranium chips will be located immediately adjacent to the excavation site and ready for use by trained personnel. Soils, containers, and debris will be moved to a staging/segregation area, described in Section 2.2. Activities associated with excavation of T-1 include:

- Removal of soil, containers, and debris from trench,
  - Screening soil for radiological activity and potential VOCs
  - Segregating/stockpiling soil in preparation for packaging for off-site shipment or eventual backfill use

* Removing containers, debris, and any unknowns and handling accordingly
  - Breaching the containers in the trench (i.e. piercing drum lids, breaking drum lid seals) to relieve any pressure buildup and to facilitate inspection
  - Removing containers, debris, or unknowns from trench and performing radiological and chemical characterizations
  - Transporting containers to a container handling area for evaluation and segregation of container contents
  - Packaging non-hazardous debris in crates and transferring to staging area
  - Managing/packaging hazardous debris (radiological or VOCs) for disposal
- Removing slough material, screening, segregating, packaging, and transporting to handling area, and
- Removing any contaminated soils and performing verification sampling.

Excavation of T-1 will be by rows across the width of the trench. A single row is expected to contain between 10 and 12 containers (5-6 55-gallon drums across, stacked two high). Because of the pyrophoric nature of depleted uranium chips, the number of containers that will be simultaneously uncovered and exposed will be minimized. At most, a single row (12 containers) will be excavated and exposed prior to beginning the next row. If two side-by-side rows of containers are in close proximity during single row excavation (in other words, not separated by adequate earthen material to preclude disturbance) no more than 12 containers will be exposed before advancing the excavation, regardless of which row the containers are located. This maximum number of exposed containers (those containing depleted uranium chips/turnings) includes the number of containers uncovered inside the trench as well as the number of containers being handled at the staging/segregation area adjacent to the trench. All excavated combustible materials (e.g., depleted uranium chips/turnings, liquids and sludge, and waste materials such as paper, wood, PPE, etc.) will be either reburied or placed in closed metal containers at the end of each work shift to prevent potential fires during off-shift hours.

2.2 Staging/Segregation/Packaging of Contaminated Materials and Soil

The staging and segregation area is located adjacent to the T-1 trench along the south side as shown in Figure 1. Containers with waste materials (paper, wood, PPE, crushed drums or drum fragments, metal, rubber, plastic, etc.) will be evaluated and segregated accordingly.

Liquids and sludge, if encountered, will be screened for radiological and VOC contamination and re-packaged if required, ensuring container integrity. After container integrity is assured, the liquids will be stored within secondary containment for later processing.

Uranium chips/turnings to be inerted will be transported to the SIP. Material identified as containing uranium chips and/or uranium chips in a soil matrix will also be transported to the SIP.

Radiologically and/or VOC contaminated soil above RFCA Tier I action levels, not intimately associated with the depleted uranium waste, will be excavated, packaged, and staged for disposal.

Soils suspected to be contaminated at less than RFCA Tier I action levels will be stock-piled for reuse in backfilling the trench. As a contingency, if sufficient VOC-contaminated soils and debris are present to justify the expense, a low-temperature TDU will be used to remove the VOCs from the contaminated soils in a non-destructive manner. If thermal desorption is used, the TDU will be similar to that described in the Mound Proposed Action Memorandum (PAM) (Ref. 14). Soil would be staged pending mobilization of a TDU. Activities associated with staging/segregation of excavated material include:

- Receipt of containers and other wastes to be segregated,
- Determining if containers are holding waste (liquids, solids, sludge),
- Removing contents from containers for disposition (using manual and automated techniques),
- Transferring liquids and sludge to appropriate containers (if necessary), sampling, and managing for appropriate disposal,
- Transferring depleted uranium chips/turnings to the SIP, and
- Managing remaining solids for appropriate disposal.

Materials that cannot be immediately identified will be repackaged, and sampled to identify the contents. Once the material is identified, it will be disposed of properly.

2.3 Sampling and Inerting of Depleted Uranium Chips/Turnings

Sampling and inerting of depleted uranium chips/turnings will be performed at the SIP located within the temporary structure. The SIP is located approximately 25 feet from the southwest corner of the T-1 trench as shown in Figure 1. The inerting of depleted uranium chips/turnings has been subcontracted to the Starmet Corporation headquartered in Concord, Massachusetts. Department of Transportation (DOT) accepted methods will be utilized to inert metal uranium chips/turnings and incidental radioactivity contaminated soils in preparation of off-site shipment.

Excavated depleted uranium containers with sufficient structural integrity will be loaded into 83-gallon DOT Type 7A Specification containers appropriate for pyrophoric Class 7 (radioactive) materials and inerted by covering with mineral oil. Any lathe coolant that is present will be pumped from intact containers prior to adding mineral oil. The overpack container will then be sealed. Inerting the depleted uranium by adding mineral oil isolates the uranium from oxygen and moisture, rendering it stable and non-pyrophoric.

Depleted uranium chips that are commingled within a soil matrix will be containerized in Type 7A large metal boxes. Additional dry soil will be added as required to the top of the container to exclude all oxygen that might potentially react with any metallic uranium in the soil. The soil serves three functions (1) it serves as a dispersant to reduce the average concentration of potentially pyrophoric material to levels that would not sustain a reaction, (2) it excludes air by occupying all of the space in the box, and (3) it functions as a heat transfer medium to insure that heat from any localized region of slow oxidation is dissipated.

After inerting and packaging the depleted uranium material, the Type 7A Specification containers (83-gallon drums or large metal boxes) will be transferred out of the tent structure and temporarily stored in SEALAND containers (or other appropriate shelter) at the packaged material staging area (located outside of the temporary structure) prior to loading the material for transport. This shipping concept is compliant with DOT 49 CFR Part 173.418, *Authorized Packages-Pyrophoric Class 7 (Radioactive) Materials*, for pyrophoric Class 7 radioactive materials, (Ref. 15).

The inerting of depleted uranium chips/turnings will utilize "batch" mode processing with no more than the equivalent of six containers (assumed to be 55-gallon drums) being processed at a time. Activities associated with the inerting of depleted uranium chips/turnings include:

- Receiving depleted uranium for inerting from the staging/segregation area,
- Manual and automated movement/handling of uranium chips/turnings,
- Inerting depleted uranium and packaging it in DOT Type 7A Specification containers appropriate for pyrophoric Class 7 (radioactive) materials in preparation for off-site shipment, and
- Transferring inerted material to a staging area within the temporary structure and subsequently to the packaged material storage area outside the temporary structure until shipment.

2.4 Storage of Contaminated Materials and Soil

Subsequent to packaging contaminated materials/soil and inerted depleted uranium chips/turnings these wastes will be stored at the material storage area outside the temporary structure until eventual shipment to another on-site location or for off-site treatment/final disposition. The material storage area is located to the north and west of the north-south running leg of the temporary structure away from Central Avenue and other site access roads.

The proposed waste storage and management methods will preclude a fire from occurring at the material storage area that would exceed the radiological dose consequences of accident scenarios postulated to occur during excavation, staging/segregation/packaging, or sampling and inerting activities (i.e., a spill or fire involving 2,000 kg depleted uranium; the contents of twelve 55-gallon drums as discussed in Sections 4.4.3, *Fires*, and 4.4.4 *Spills*.). The quantity of radioactive material that could be impacted during a fire (which bounds a spill involving the same quantity of material) and released to the atmosphere is minimized by material packaging and use of appropriate airborne release fractions (ARF) as discussed below.

Material Packaging – waste material stored at the T-1 site will be packaged in DOT approved metal shipping containers with filter vents. Metal drums will be used to overpack depleted uranium excavated from the trench. In most cases two overpack drums will be used to package the waste. An intact or partially intact 55-gallon drum of depleted uranium removed from the trench will be placed in an 83-gallon overpack drum, flooded with mineral oil, and placed in a second 110-gallon overpack drum. Depleted uranium commingled with soil will be placed in metal waste boxes and inerted with soil. The metal waste containers, specifically the waste drums, are relied upon to (1) retain container lids due to internal overpressures from exposure to expected fires, and (2) preclude the propagation of fire from one container to another.

Airborne Release Fraction (ARF) – the ARF chosen to model a large fire involving waste material stored at the T-1 material storage area is 9.75×10^{-4}. This ARF is based on a fire that causes drum heating and eventual combustion of the mineral oil inside the drum. The mineral oil is expected to have some depleted uranium suspended in the liquid. The amount of depleted uranium suspended in the mineral oil is assumed to be less than 5% of the total amount in the container. As the mineral oil combusts, the drum lid seal and/or filter vent is expected to fail venting the burning mineral oil. For this portion of the release an ARF of 1×10^{-2} is applied, which is the bounding ARF for quiescent buring or small-scale pool burning of combustible liquids containing radionuclides. As the mineral oil continues to be consumed, the depleted uranium chips/turnings will begin to combust as a confined material release with an ARF of 5×10^{-4} applied. The combined ARF for this fire scenario is therefore 9.75×10^{-4} $[0.05 \times (1 \times 10^{-2}) + 0.95 \times (5 \times 10^{-4})]$. Using an ARF of 9.75×10^{-4} versus an ARF of 1×10^{-2} for an unconfined depleted uranium chips/turnings (used for the fire scenario occurring during excavation), results in a reduction in dose consequences by a factor of approximately 10 $(1 \times 10^{-2}/9.75 \times 10^{-4})$. Therefore, 10 times more material would have to be involved in a fire at the material storage area than in a fire involving unconfined depleted uranium chips/turnings occurring during excavation. The excavation fire scenario postulates a MAR of 2,000 kg of unconfined depleted uranium, therefore, a fire scenario involving up to 40,000 kg of confined depleted uranium at the material storage area would be bounded. Section 4.4.3 further discusses the excavation fire scenario.

Once radiological material is released to the environment, the radiological dose to the public and the collocated worker is affected by the atmospheric dispersion factor (χ/Q expressed in s/m^3) associated with the scenario. The smaller the χ/Q, the greater the dispersion of radioactivity, and the lower the radiological dose. Lofted versus non-lofted fires and associated atmospheric dispersion are discussed below.

Lofted versus Non-lofted Fire – A fire that could involve up to 40,000 kg of depleted uranium packaged in metal containers is considered a large fire and would be modeled as a lofted plume. The excavation fire scenario involving 2,000 kg of unconfined depleted uranium has been modeled as a non-lofted plume because pyrophoric depleted uranium fires are smoldering slow burning fires. The χ/Q for the public and the collocated worker are smaller for a lofted fire than they are for a non-lofted fire. As a result, the dose consequence to the public is reduced by a factor of 8 for a lofted fire versus a non-lofted fire. Similarly, the dose consequence to the collocated worker is reduced by a factor of 27 for a lofted fire versus a non-lofted fire.

The following controls are credited to reduce the frequency of a fire at the material storage area:

- Concrete barriers (*e.g.*, jersey barriers) provide separation of the material storage area from transient combustibles and reduce the possibility of a fuel spill and ensuing pool fire occurring near the stored material.
- Control of ignition sources at the material storage area prevents a fire from starting due to operational events (*e.g.*, hot work) or human error (*e.g.*, smoking).

The controls discussed above are also documented in Chapter 5, *Hazard Controls.*

Based on the above discussion, a postulated fire at the material storage area involving up to 160,000 kg of depleted uranium modeled as a lofted fire, 10-minute release duration, with an ARF of 9.75×10^{-4} would be bounded by a fire postulated to occur at the trench during excavation, segregation/staging/packaging, or sampling/inerting involving 2,000 kg of depleted uranium modeled as a non-lofted plume, 10-minute release duration, with an ARF of 1.0×10^{-2}. The 160,000 kg of material was detemined by multiplying (1) 2,000 kg of material postulated to be involved in the excvation fire scenario, (2) a factor of 10 to account for the smaller ARF, and (3) a factor of 8 to account for a lofted plume fire. Since a conservative estimate of the amount of material stored at the material storage area is approximately 55,000 kg of depleted uranium, fires at the material storage area are bounded by the excavation fire scenario and are not further evaluated in Section 4.4, *Accident Analysis.*

2.5 On-Site Transportation of Inerted Material

The on-site transportation of inerted depleted uranium will be compliant with DOT 49 CFR Part 173.418 (Ref. 15) for off-site over-the-road transportation. RMRS will assure that testing and certification data are provided to document that all containers meet DOT criteria for Specification 7A packaging appropriate for pyrophoric Class 7 (radioactive) materials. DOT 49 CFR Part 173.418 criteria includes the maximum activity of depleted uranium permitted in a single Type 7A container. Containers will be packaged to meet this criteria. Containers will be vented to preclude hydrogen gas buildup during transportation. Shipments to Starmet will be by qualified common carrier in closed vans, in "exclusive use."

After processing of potentially pyrophoric soil and commingled depleted uranium at Starmet, the non-pyrophoric, agglomerated and volume-reduced waste form will be loaded into the empty metal boxes originally used to ship the material to Starmet. After labeling and inspection, the boxes will be turned over to an RMRS representative for further disposition.

2.6 Backfilling Trench

Subsequent to removing contaminated materials and soils from the trench, it will be backfilled with clean soil, soil with less than 25,000 counts per minute (cpm) excavated from the trench during source removal activities, and Investigative Derived Material (IDM). All of the backfill material will meet previously accepted putback criteria. Up to 2,500 containers or 600 yd^3 of IDM, generated from past environmental restoration activities such as borehole drilling and soil sampling, will be placed into the trench. Activities associated with placement of IDM into the trench include:

- Receipt of containers (primarily 30- and 55-gallon drums) at the T-1 site,
- Movement of IDM containers to trench side using a forklift and drum grabbber,
- Opening of containers using hand tools (e.g., wrenches, sawsall, etc.),
- Dumping the contents of the containers next to the trench utilizing a drum turner,
- Segregating waste not intended to be placed into the trench,
- Movement of soil into the trench using a front-end loader, and
- Grading the trench.

Sampling and characterization data indicates that the IDM proposed for placement into the trench contains very small concentrations of ^{241}Am, ^{239}Pu, ^{233}U, ^{235}U, and ^{238}U. The IDM radionuclide concentrations are less than RFCA Tier II Action Levels for these radionuclides. Safety Evaluation Screen SES-TR1-99.0086-JSK (Ref. 16) concludes that the placement of IDM into the trench is bounded by the safety analysis presented in Section 4. Therefore, IDM placement into the trench can be accomplished safely and is not further evaluated.

2.7 Site Reclamation

At the completion of remediation activities, radiological surveys of the T-1 Site excavation and treatment areas will be performed and the areas will be revegetated. Radiological surveys of the equipment will be performed per the RFETS Radiological Control Manual (Ref. 17). Excavation, sampling, inerting, and all other support equipment will be decontaminated to a release level or disposed of as low level waste.

3. SITE CHARACTERIZATION

Drums of waste from Building 444 casting, machining, and fabricating operations were first placed in T-1 in November 1954 and burial operations continued intermittently until December 1962. Wastes were initially buried in T-1 when Building 444 could not safely process drums of depleted uranium turnings that were combustible and presented a fire hazard. The depleted uranium chips were in drums that also contained lathe coolant (primarily a mixture of water, mineral oil, and fatty amides), dirt, and other foreign material. Historical information indicates that other wastes are buried in T-1 including ten drums of cemented cyanide and one drum of "still bottoms" and "copper alloy." The east end of the trench is expected to contain crushed drums, broken pallets, debris and trash.

The information presented in this section of the safety analysis was taken from References 1 and 2 and reflects the current project characterization of T-1. The characterization information presented in the following paragraphs does not discuss the presence of unforeseen and/or uncharacterized conditions. The project controls listed in Table 5-1 assure that unforeseen/uncharacterized hazards will be identified as the project progresses and controlled subsequent to discovery.

3.1 Existing Trench Conditions

The T-1 area was investigated during the Operable Unit 2 (OU 2) Phase II RCRA Field Investigation/Remedial Investigation (RFI/RI) Program. Additional characterization was conducted as part of the 1995 Trenches and Mound Site investigation. The 1995 investigation included a historical data search, examination of aerial photographs, a site visual survey, electromagnetic and ground penetrating radar surveys, and soil gas surveys. Due to the suspected presence of pyrophoric uranium and its associated hazards, no drilling or subsurface sampling was performed inside of the T-1 boundaries.

Historical records and information obtained through employee interviews indicate that as many as 125 30-gallon and 55-gallon steel drums containing depleted uranium chips and turnings and miscellaneous debris were disposed in T-1. Drum inventory lists, memoranda, and drum shipping logs documenting the placement of 85 drums have been located. The uranium chips and turnings were coated with a water-soluble lathe coolant (trade name Cimcool®) used during machining of parts. Several of the drums containing depleted uranium and lathe coolant are described as 30-gallon drums placed inside 55-gallon drums and over packed with graphite.

Inventory records also include ten drums of cemented cyanide waste from Building 444. A drum of "still bottoms," also from Building 444, potentially consists of either lathe coolant sludge or still bottoms from the recovery of residual trichloroethene and perchlorethene waste solvents and sludge generated from machined parts cleaning.

The buried containers are thought to have been double-stacked in the trench on-end (vertically), in rows of 5 to 6 containers across. The trench is estimated to be approximately 10 feet deep, 16 to 22 feet wide, and 200 to 250 feet long. The bulk of the containers with depleted uranium was reportedly buried in the west portion of the trench. Individual groups of drums are expected to be completely covered with one to two feet of soil. Miscellaneous debris was placed mostly in the central and eastern portions of the trench and also covered with one to two feet of soil.

Weed cutting activities in October and November 1982 unearthed two drums not adequately covered with fill material. Both drums were sampled and were to be removed for off-site disposal. One drum contained an oil/water mixture that yielded plutonium analyses of 55 pico-curies per liter (pCi/l) and uranium analyses of 2.3×10^5 pCi/l. The other drum was found to contain an oily sludge that yielded results of 4.3 pico-curies per gram (pCi/g) plutonium and 1.2×10^6 pCi/g uranium.

3.2 Buried Drums Characterization

3.2.1 Radionuclides

Based on historical information from the environmental master file, retired worker interviews, and site characterization, it is anticipated that the total radiological material inventory at T-1 could be as much as 10,000 to 20,000 kg of depleted uranium chips and turnings. The dominant isotope of depleted uranium is ^{238}U.

3.2.2 Liquids, Solids, and Sludges

Liquids, solids and sludges that are anticipated as being present in the buried waste containers include: lathe coolant (Cimcool®) in containers with depleted uranium chips, 10 drums of cemented cyanide waste, and sludges generated from machine parts cleaning.

3.3 Soil Characterization

3.3.1 Radionuclides

Available analytical results of radionuclide sampling of the soils at T-1 are summarized in Table 3-1. These results are from three boreholes located near, but outside, the boundaries of the T-1 excavation area. Plutonium 239/240 and americium-241 activities detected in each of the three boreholes generally decreased with depth, indicating the sources of these radionuclides are likely present in or near the surface. The maximum plutonium-239/240 and americium-241 activities were detected in the 0-12 foot depth sample from borehole BH3587. The maximum uranium-238 activity was detected in the 18-20 foot depth sample from borehole BH3687. It is anticipated that uranium activities in subsurface soil immediately beneath T-1 will exceed the RFCA Tier II subsurface soil action level of 103 pCi/g. For the purpose of this safety analysis, a ^{238}U concentration of 103 pCi/g is conservatively assumed to be present throughout the soils in the T-1 excavation area.

Table 3-1 Concentration of Radionuclides in Soils Near T-1 Excavation

Radionuclide	Maximum Concentration (pCi/g) (Detected in Boreholes BH3487, BH3587, and BH3687)
Uranium 238	2.2
Plutonium 239/240	1.5
Americium 241	0.4

Note: None of these concentrations exceed the RFCA Tier II Subsurface Soil Action Levels, which are based on an annual dose limit of 15 millirem to a hypothetical future resident (based on presence of a single radionuclide only).

3.3.2 Volatile Organic Compounds

Subsurface soil samples were collected from three boreholes (BH3487, BH3587, and BH3687) in the vicinity of T-1. Subsurface soil sampling from beneath the bottom of the trench was attempted but was unsuccessful. In addition, a limited soil gas survey was performed at the trench site to screen for VOCs.

Results from the Phase II RFI/RI investigations and the Trenches and Mound Site Characterization indicate that no VOC, semivolatile organic compound (SVOC), or polychlorinated biphenyls (PCB) concentrations detected in the vicinity of T-1 exceed the RFCA Tier II subsurface soil action levels.

In addition, soil gas samples were collected at depths of five to ten feet below ground surface at 25 sample locations around the perimeter of the trench to screen for total volatile organic compounds (TVOCs) using an organic vapor analyzer. No samples were collected within the trench boundaries because of the suspected presence and potential hazards associated with pyrophoric depleted uranium. Based on the sampling data taken near the trench, it has reasonably been concluded that T-1 is not a major source of TVOCs (Ref. 2)

3.3.3 Metals

Cadmium was detected in subsurface soil samples collected from boreholes located near, but outside, the boundaries of the T-1 excavation area. The detected levels are from boreholes BH3487 [2.0 to 3.1 milligrams per kilogram (mg/kg)], BH3587 (2.2 to 3.3 mg/kg), and BH3687 (2.0 to 2.4 mg/kg). These concentrations are below both the Tier I and Tier II action levels for cadmium in subsurface soils in the proposed open space area. Arsenic was detected at 14 mg/kg in borehole BH3587 at a depth of 18 to 19 feet. This concentration is below Tier I and above Tier II action levels for arsenic in subsurface soils in the proposed open space area.

3.4 Support Trailers

A cluster of five trailers will be used to support the T-1 Source Removal Project. These trailers are designated as T900C, T900D, T900E, T900F, and T900G and support the following project activities:

Support Trailer	Activities
T900C	Gamma Spectroscopy
T900D	Gamma Spectroscopy Subcontractor Office Area Radiological Control Technician Office Area
T900E	PPE Dressout Storage of Clean PPE Treatment Subcontractor Office Area
T900F	Project Management Meeting Area Health and Safety Staff Support Office Area
T900G	Project Management Office Space Radiological Operations Support Office Area Sample Management and Waste Management

Trailer T900C will receive soil, water, waste, debris, and depleted uranium samples for gamma spectroscopy to confirm the radionuclides present and to determine if the samples are above RFCA Tier I action levels or other project/waste management specific requirements. The portion of the trailer where gamma spectroscopy will be performed will be appropriately posted indicating the radiological conditions present. The potential for airborne radioactivity is extremely unlikely because only radioactive soil samples will be opened in the trailer and the samples will be opened under the T900C High Efficiency Particulate Air (HEPA) lab hood. Any sample opened will not exceed 4.1 nanocuries/gram for ^{241}Am, $^{239/240}$Pu, ^{234}U, ^{235}U, or ^{238}U (Ref. 18). Assuming that the contents of a 500 ml sample jar are spilled in T900C, approximately 3,280 nanocuries of contamination would potentially be available for airborne release (Ref. 18). Nanocurie quantities of ^{241}Am, $^{239/240}Pu$, ^{234}U, ^{235}U, or ^{238}U are much less than the Nuclear Facility Hazard Category 3 thresholds specified in DOE-STD-1027 (Ref. 8). A sample spilled in T900C, including a depleted uranium sample, is bounded by a spill of 2,000 kgs of depleted uranium within the temporary structure and is not further evaluated in this safety analysis. All activities conducted in T900C will be performed by trained individuals under a job-specific Radiological Work Permit (RWP) and a As Low As Reasonably Achievable (ALARA) Job Review.

Trailers T900D, T900E, and T900F will not contain any radioactive materials. Trailer T900F may contain negligible quantities of hazardous chemicals (e.g., calibration gases). Trailer T900G will be used by Radiological Operations to analyze radiological smears and air samples. Sample management and waste management activities will also be performed in T900G. The trailer will be appropriately posted indicating the radiological conditions present. Samples will be stored in a locked steel container or locked in a sample storage freezer. Samples stored in T900G will not be opened, minimizing the potential for an airborne release. If a sample were spilled in T900G it would be a similar scenario to that in T900C, which is bounded by a spill of 2,000 kgs of depleted uranium within the temporary structure, and is not further evaluated in this safety analysis.

4. SAFETY ANALYSIS

4.1 Hazard Categorization - Radiological

The total activity of each identified radionuclide potentially present in the soil at the T-1 excavation, assumed to be 2,100 yd^3 of soil, was estimated using the formula below and the maximum concentrations from Table 3-1. It is assumed that these concentrations are present in the T-1 soils. The ratios of: (1) the total activity to the Category 3 thresholds in DOE-STD-1027-92, and (2) the total activity to the 40 CFR 302 Appendix B RQs were determined for each radionuclide for facility/site categorization purposes. Results are provided in Table 4-1.

A_T = Total Activity (pCi) = A x ρ x V

A = maximum activity concentration, pCi/g from Table 3-1

ρ = soil density = 1.8 g/cm^3

V = soil volume excavated = 2,100 yd^3 = 56,700 ft^3

The total activity for each isotope detected in the soil near the T-1 excavation area was calculated as follows:

<u>For ^{238}U</u>

$A_T = 103 \text{ pCi/g} \times 1.8 \text{ g/cm}^3 \times 56{,}700 \text{ ft}^3 \times (1 \text{ cm}^3/3.53 \times 10^{-5} \text{ ft}^3)$

$A_T = 2.98 \times 10^{11}$ pCi (~<u>0.30 Ci</u>)

<u>For $^{239}Pu/^{240}Pu$</u>

$A_T = 1.5 \text{ pCi/g} \times 1.8 \text{ g/cm}^3 \times 56{,}700 \text{ ft}^3 \times (1 \text{ cm}^3/3.53 \times 10^{-5} \text{ ft}^3)$

$A_T = 4.34 \times 10^{9}$ pCi (~<u>0.004 Ci</u>)

For ^{241}Am

A_T = 0.40 pCi/g x 1.8 g/cm^3 x 56,700 ft^3 x (1 cm^3/3.53 x 10^{-5} ft^3)

A_T = 1.16 x 10^9 pCi (~0.001 Ci)

The total activity of radionuclides (primarily ^{238}U) in the buried waste containers at T-1 has been estimated to be between 3.4 and 6.8 curies (the activity associated with a total inventory of 10,000 - 20,000 kgs of depleted uranium chips). The upper bound of 6.8 curies exceeds the Nuclear Facility Category 3 threshold of 4.2 curies as specified in DOE-STD-1027-92, Attachment 1 (Ref. 7). However, when comparing radionuclide quantity or activity to the DOE-STD-1027-92 thresholds for facility/site categorization purposes, the standard allows the analyst to compare the quantity from a designated facility/site "segment" provided the hazardous material in one segment can not interact with hazardous materials in other segments. This facility/site segmentation concept has been applied to the T-1 facility categorization and is discussed below.

Segmentation

Although the total inventory of depleted uranium (primarily ^{238}U), or Material-at-Risk (MAR), at the T-1 excavation potentially exceeds the threshold amount for a Nuclear Facility Hazard Category 3 as shown in Table 4-1, not all of the material will be available for release by a common cause release mechanism such as a fire or spill. Segmentation, as defined in DOE-STD-1027-92, is "the division of the total hazardous material inventory of a facility into segments for which common cause phenomena (typically, but not limited to severe accident types such as fires, explosions, earthquakes, and floods) would not result in bringing material together or causing harmful interaction in more than one designated segment."

Table 4-1 Radionuclide Quantities at T-1 (Soil and Drums)

Radionuclide	Total Activity, Ci	DOE-STD-1027, Attachment 1 Category 3 Threshold, Ci	40 CFR 302.4 Appendix B RQ, Ci	Ratio (Activity/1027 Threshold)	Ratio (Activity/RQ)
Radionuclides in 2,000 yd^3 Soil					
Uranium 238	0.30	4.2	0.1	0.071	3
Plutonium 239/240	0.004	0.52	0.01	0.0077	0.4
Americium 241	0.001	0.52	0.01	0.0019	0.1
Total Sum-of-Ratios				0.08	>1
Radionuclides in Drums					
Uranium 238	3.4 - 6.8 (10,000 kg-20,000 kg)	4.2	0.1		
Total Activity is Potentially > Category 3 Threshold without crediting "segmentation"					

Credit is taken for segmentation of the T-1 Source Removal Project so that a single designated "segment" contains less than the Category 3 threshold amount of ^{238}U specified in DOE-STD-1027-92. For the T-1 Source Removal Project, a segment is defined, and controlled, as an excavation amount (typically a single row in the trench) containing not more than 12 containers of depleted uranium chips. Segmentation for the T-1 Source Removal Project includes:

1. Excavation techniques that minimize the number of containers and amount of depleted uranium exposed and available for airborne release: Not more than 12 containers, estimated to be approximately 2,000 kgs of depleted uranium, will be exposed during excavation activities at the trench. The Nuclear Facility Hazard Category 3 threshold for ^{238}U, as specified in DOE-STD-1027-92, is 13,000 kgs. The margin between the 2,000 kgs of MAR contained in the segment being excavated and the 13,000 kgs Nuclear Facility Hazard Category 3 threshold amount assures that the threshold will not be exceeded. This is adequate margin to allow for inventory uncertainty and loose depleted uranium chips/turnings in the trench due to container degradation. Additionally, project procedures will minimize, to the greatest extent practical, the number of containers and the amount of depleted uranium exposed during excavation activities further reducing the MAR. This segmented excavation methodology minimizes the possibility of bringing a quantity of material together that, if involved in a fire or spill, could result in unacceptable risk to the collocated worker, the public, or the environment.

2. Earthen cover barrier between segments: Earthen cover protects the buried containers against disturbance and eliminates the possibility of an airborne release of depleted uranium (the airborne release fraction is assumed to be zero for undisturbed buried containers). The earthen cover is considered a passive barrier providing segregation between material in the portion of the trench being excavated and the material contained in the remainder of the trench.

3. "Single Batch" processing during sampling and inerting process activities: Single batch processing minimizes the MAR that could be involved in a postulated accident scenario and assures that the postulated fire and spill scenarios in Section 4.4, for excavation, staging/segregation, and sampling and inerting process activities, are bounding. A single batch for sampling and inerting process activities will not exceed six (6) previously buried containers providing additional margin between the MAR quantity and the Nuclear Facility Hazard Category 3 threshold quantity.

4. On-site staging and transportation of inerted depleted uranium material will involve material quantities below the Nuclear Facility Hazard Category 3 threshold amount.

Controls that assure segmentation of the trench are credited in Hazard Assessment Tables 4-5 and 4-6 and described in Table 5-1, *Project Hazard Controls.*

By crediting segmentation, the MAR contained in a single segment is estimated to be 12/125 (125 being the expected total number of depleted uranium containers in the trench) or approximately 10% of the total material contained in the trench. Conservatively assuming a total radiological material inventory of 20,000 kgs of depleted uranium in the trench, the MAR is 10% of 20,000 kgs or 2,000 kgs. This value was compared to DOE-STD-1027-92 thresholds for facility/site categorization as summarized in Section 4.3.

4.2 Hazard Classification - Chemical

The hazard classification for chemicals is assigned based on a comparison of the T-1 Site chemical inventory to the TQs in OSHA Standard 29 CFR 1910.119 (Ref. 8), the TQs in EPA Rule 40 CFR 68 (Ref. 9), the TPQs in 40 CFR 355 (Ref. 10), and the potential for an airborne release of a hazardous material. If any of these thresholds are exceeded, additional analysis is required to determine the consequences of an airborne release of a hazardous material to workers, the public, and the environment.

Table 4-2 identifies chemicals that are common to some of the other source removal sites near the T-1 excavation, namely Trench3/Trench4 (T3/T4) and the Mound Site. The table shows which chemicals have regulatory thresholds (RQs, TQs or TPQs). The RQs in 40 CFR 302 are used to establish the dividing line between radiological or non-nuclear facilities and other industrial facilities. Reportable quantities are based on the potential release of materials into the environment and are not based on the toxicological effects to humans. Releasing a quantity to the environment that is greater than the RQ, for a listed chemical, requires compliance with applicable reporting requirements. Consequence analysis of such a release is not required unless one of the other thresholds is also exceeded.

Site characterization data indicates that VOC and SVOC concentrations at the T-1 Site excavation do not exceed threshold quantities specified in the above mentioned OSHA and EPA regulations. Therefore, activities associated with the T-1 Project are not expected to result in any airborne releases of hazardous materials that could affect off-site personnel (off-site is defined as the collocated worker and the public) or the environment.

Table 4-2 Common Chemicals Found in Soils at RFETS Remediation Projects

Chemical	29 CFR 1910.119 TQ (kg)	40 CFR 68 TQ (kg)	40 CFR 302.4 RQ, (kg)	40 CFR 355 TPQ (kg)
Carbon Tetrachloride	not listed	not listed	4.54	not listed
Methylene Chloride	not listed	not listed	454	not listed
Perchloroethylene (PCE)	not listed	not listed	45.4	not listed
Trichloroethylene (TCE)	not listed	not listed	45.4	not listed
Hydrofluoric Acid	454 (anhydrous)	454 (conc ≥ 50%)	45.4	45.4
Arsenic	not listed	not listed	**	not listed
Cyanide	not listed	not listed	**	not listed

** Indicates that no RQ is being assigned to the generic or broad class.

4.3 Preliminary Hazard Categorization

Based on the guidance in DOE-STD-5502-94 and project characterization data, the T-1 Source Removal Project is classified as radiological requiring compliance with applicable OSHA Standards, preparation of a site-specific HASP, and preparation of an "auditable safety analysis." This classification was determined as follows:

- Potentially releasable radioactive material <u>does not meet or exceed</u> DOE-STD-1027-92, Attachment 1, Nuclear Facility Hazard Category 3 thresholds based on an estimation of the MAR crediting segmentation (refer to Section 4.1), and
- Potentially releasable radioactive material <u>exceeds</u> 40 CFR 302, Appendix B RQ levels (see Table 4-1).

In addition, the T-1 Project presents a *low* hazard to workers, the public, and the environment based on the chemical inventory and potential airborne releases (refer to Section 4.2). A *low* classification is defined as "hazards which present minor on-site and negligible off-site impacts to people and the environment" (Ref. 3).

This safety analysis serves as the "auditable safety analysis" required to meet DOE-STD-5502-94. The T-1 site-specific HASP provides: (1) systematic identification of radiological, chemical, physical, and biological hazards associated with source removal activities, (2) description and analysis of the adequacy of the measures taken to eliminate, control, or mitigate identified hazards, and (3) analysis and evaluation of potential accidents.

4.4 Accident Analysis

Radiological hazards associated with the T-1 source removal activities present negligible off-site impacts to people and the environment. However, since segmentation is credited in categorizing the site as *radiological*, several accident scenarios were evaluated to determine the potential risk to the collocated worker and/or the public. The postulated accident scenarios fall into one of four types: (1) fires, (2) spills, (3) explosion, or (4) transportation accidents.

No accident scenarios resulting in an airborne release of hazardous chemicals were postulated since it is not expected that VOCs, SVOCs, and PCBs are present at T-1 in significant quantities that would warrant such analyses.

Occupational hazards, including common industrial hazards (chemical exposures, biological hazards, and physical hazards), are identified and evaluated in the site-specific HASP (Ref. 1) and are clearly regulated by DOE-prescribed occupational safety and health standards. No specific analysis was performed for these types of hazards as part of this safety analysis.

4.4.1 <u>Risk Classification Methodology/Acceptance Criteria</u>

The risks identified in the accident analysis tables for the postulated accident scenarios (Tables 4-5 through 4-7) can be classified according to a combination of the expected frequency and consequence, as shown in Table 4-3. For the purpose of this document, Class I risks are considered *major*, Class II risks are *serious*, Class III are *marginal*, and Class IV are *negligible*. The risk associated with Risk Class III or IV scenarios is generally acceptable to the DOE Rocky Flats Field Office (RFFO). Accident scenarios falling into Risk Class I or II require further evaluation to determine if any preventive or mitigative derived controls could reduce the Risk Class to a III or IV.

In accordance with the *Guidance for Preparation of DOE 5480.22 (TSR) and DOE 5480.23 (SAR) Implementation Plans*, DOE-STD-3011-94 (Ref. 19), events more frequent than

10^{-2}/ year are classified as *anticipated*, those between 10^{-4} and 10^{-2}/year are classified as *unlikely*, and those less frequent than 10^{-4}/year are classified as *extremely unlikely*. These terms are consistent with the usage in the *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports*, DOE-STD-3009-94 (Ref. 20). For safety analysis purposes, the *extremely unlikely* category also includes non-credible (i.e., less than 10^{-6}/yr) but potentially high-risk scenarios, as discussed in DOE-STD-3011-94, in those instances where the risk potential is judged significant to the assurance of safe operations. Estimates of frequency are qualitative.

Table 4-3 Risk Classes - Frequency vs. Consequences

	FREQUENCY OF OCCURRENCE (per year)		
CONSEQUENCE	**Extremely Unlikely <10^{-4}**	**Unlikely 10^{-4} - 10^{-2}**	**Anticipated >10^{-2}**
HIGH	II	I	I
MODERATE	III	II	I
LOW	IV	III	III

4.4.2 Radiological Risk

Consequence levels for radiological accidents are determined using the comparison criteria shown in Table 4-4. For non-lofted plumes, the shortest possible distance from the T-1 excavation to the Site boundary (the public receptor) was estimated to be 2,200 meters, using the methodology in RFP-4911, *Tools and Methodology for Collocated-Worker Consequence Assessments* (Ref. 21) and the *Safety Analysis and Risk Management Handbook (SARAH)* (Ref. 22).

The collocated worker consequences have been evaluated at 100 meters from the T-1 excavation even though DOE-STD-3011-94 suggests (but does not require) using 600 meters. This approach is more conservative for ground-level (non-lofted) releases and is appropriate for the following reasons: (1) many collocated workers may be closer to the T-1 excavation than 600 meters due to the compactness of the Site, (2) collocated workers 100 meters from an accident would be aware of the accident due to noise, smoke, or a dust cloud, and (3) the minimum distance usable by the Gaussian plume formulation used by the RADIDOSE spreadsheet, *Radiological Dose Template* (Ref. 4-23), is 100 meters.

Table 4-4 Radiological Accident Consequence Levels

CONSEQUENCE	**PUBLIC DOSE** (at 2,200 meters)	**COLLOCATED WORKER DOSE** (at 100 meters)
HIGH	> 5 rem	>25 rem
MODERATE	> 0.1 rem	> 0.5 rem
LOW	≤ 0.1 rem	≤ 0.5 rem

The term "immediate worker" is used to describe the worker who could be located immediately adjacent to the release location or within the T-1 Site boundaries. For immediate worker consequences, qualitative judgments of acute radiological effects were made since the minimum distance usable by the Gaussian plume formulation used by the RADIDOSE spreedsheet is 100 meters. They do not include latent cancer effects, per DOE-STD-3011-94.

Radiological doses are determined using the methodology described in the *Radiological Dose Template* and are documented, along with the accompanying assumptions, in calculation 97-SAE-010 (Ref. 5) *Support Calculation - Safety Analysis for Individual Hazardous Substance Site (IHSS) 108 Trench 1 (T-1) Source Removal Project.* For all postulated accident scenarios presented in Sections 4.4.3 through 4.4.5, a 95th percentile dose determination is used for comparison with the radiological accident consequence levels in Table 4-4.

4.4.3 Fires

Potential fires can occur within the trench excavation or at the staging/segregation, SIP, or packaged material staging areas. A fire involving depleted uranium chips/turnings is most likely to occur when the material is first exposed to the atmosphere. The depleted uranium chips/turnings will be inerted with mineral oil after removal from the excavation. Mineral oil is a petroleum based hydrocarbon classified as a National Fire Protection Association (NFPA) Class IIIB combustible liquid that has a flash point of 310 °F. It has an NFPA flammability hazard rating of 1, which is defined as "a material that must be preheated before ignition can occur." Subsequent to removing turnings from the trench, they will be placed in 83-gallon overpack drums at the staging/segregation area and then moved to the SIP area.

A potential fire accident scenario could occur at the SIP when inerting the depleted uranium chips/turning with mineral oil. The mineral oil could potentially ignite if poured onto depleted uranium metal that is undergoing a thermal reaction. However, based on its NFPA flammability hazard rating of 1, it would have to be preheated prior to pouring it over the depleted uranium chips or would have to be significantly heated by the depleted uranium in order for it to ignite. Unless the depleted uranium is visibly burning it is unlikely that the mineral oil would be ignited. Controls that preclude this scenario from occurring include (1) visual inspection of the depleted uranium, while in the overpack container prior to adding the mineral oil, to assure that no visible thermal reaction is taking place, and (2) use of a temperature sensing device (i.e., infrared gun) to verify that the depleted uranium material is not undergoing a thermal reaction. Accident mitigation controls include fire department response. Preventive and mitigative controls are specified in Table 5-1, *Project Hazard Controls*. Once the material is inerted and packaged in DOT approved containers, as discussed in Section 2.3, fire scenarios are considered *extremely unlikely* and are not further evaluated.

Additional fire scenarios that could potentially occur during project activities include a fire involving fossil-fueled heavy equipment operated in the temporary structure and a fire involving excavated combustible material other then the depleted uranium chips/turnings (i.e., liquids, sludge, paper, wood, rubber, plastic, used PPE, etc.). Controls that preclude these scenarios from occurring include (1) fire extinguishers mounted on heavy equipment, (2) approved equipment refueling procedures including bonding/grounding provisions, (3) maintaining separation between heavy equipment and the temporary structure during operations and vehicle staging during off-shift hours, (4) placing excavated combustible materials in closed metal containers or covering with sufficient amounts of soil at the end of each work shift, (5) control of ignition sources, and (6) fire prevention inspections. Each of these controls are specified in the site-specific HASP Section 8, *Fire Prevention Plan*.

The analyzed fire scenario for the T-1 project, summarized in Table 4-5, is postulated to be a fire that involves the contents of 12 containers (assumed to be 55-gallon drums). The fire is assumed to occur at the excavation as a non-lofted fire with a release duration of 10 minutes. The analyzed fire scenario bounds a single 83-gallon drum fire involving depleted uranium and mineral oil based on the following considerations (1) the depleted uranium material involved in the drum fire would be approximately 1/12th the quantity analyzed for the 12 container fire, and (2) the ARF for a contaminated non-volatile liquid fire is 2.0E-03 versus 1.0E-02 for a fire involving metal chips (the material Respirable Fraction (RF) is 1.0 for both cases). The analyzed fire scenario also bounds fossil-fueled heavy equipment fires and fires involving other combustible materials because these fires would not involve quantities of depleted uranium greater than the quantity analyzed (the contents of 12 drums).

Table 4-5 Fire Scenario

Hazard	Depleted Uranium Chips/Turnings			
Accident Type	Fire (non-lofted plume) involving the contents of 12 55-Gallon Drums of material (MAR = 2,000 kgs)			
Cause or Energy Source	Spontaneous ignition when drum contents are exposed to air.			
Applicable Activity(ies)	Excavation, Segregation/Staging/Packaging, and Sampling/Inerting.			
Receptor	**Scenario Frequency**	**Consequence**	**Risk Class**	**Credited Controls ***
Public	Unlikely	Low (2.7 x 10^{-2} rem)	III	The following controls are credited as primary controls that bound or reduce accident initiation frequency and/or bound or reduce accident consequences: • Segmented excavation (1) • Earthen cover over segments not being excavated (2) • Single batch processing (not to exceed six containers) for sampling inerting process activities (3) • Fire suppression techniques for pyrophoric metals (7) • Site-specific training - pyrophoric metals fire fighting (9a) • Emergency Response Planning and Actions - HASP (10)
Collocated Worker	Unlikely	Moderate (3.3 rem)	II	Same as Public
Immediate	Unlikely	Moderate	II	• Site-Specific HASP - PPE • Emergency Response Planning and Actions - HASP (10)

* The numbers in ( ) refer to controls enumerated in Table 5-1

<u>Scenario Description</u>

The analyzed fire scenario is postulated to involve 12 containers of depleted uranium chips/turnings. This scenario is considered the bounding fire scenario based on the site characterization data documented in Section 3, *Site Characterization*. The 12 containers include the number of containers uncovered inside the trench <u>plus</u> the number of containers being managed outside the trench at the staging and segregation area. Excavation of T-1 will be by rows across the width of the trench. A single row is expected to contain between 10 and 12 containers (5-6 55-gallon drums across, stacked two high). Because of the pyrophoric nature of depleted uranium chips, the number of containers that will be simultaneously uncovered and exposed will be minimized. At most a single row (12 containers) will be excavated and exposed prior to beginning the next row. If two side-by-side rows of containers are in close proximity during single row excavation (in other words, not separated by adequate earthen material to preclude disturbance) no more than 12 containers will be exposed before advancing the excavation, regardless of which row the containers are located.

Uranium in finely divided form is readily ignited and therefore spontaneous ignition is assumed to occur when drum contents are exposed to air. Fires have occurred spontaneously in drums of coarser scrap after prolonged exposure to moist air (Ref. 24). However, it is unlikely that the contents of 12 containers will be exposed to air and spontaneously ignite. Therefore, this scenario is considered a bounding worst-case fire scenario for all activities associated with the T-1 Source Removal Project including excavation, staging/segregation, and treatment.

Accident Frequency

A small fire involving a single container of depleted uranium chips/turnings is *anticipated* to occur during excavation activities at T-1. This is due to the pyrophoric nature of depleted uranium and the fact that container lid seals will be broken exposing the contents to air. The likelihood of the postulated 12 container fire is judged to be *unlikely* based on the following considerations: (1) depleted uranium chips/turnings, the form of material in T-1, are less ignitable than more finely divided forms such as powder, (2) depleted uranium found loose in the trench has oxidized over time and is therefore less pyrophoric, (3) containers found in the trench intact will be breached, to relieve internal pressure and/or to visually inspect their contents, one at a time precluding involvement of the contents of multiple containers of depleted uranium, (4) the contents of not more than 12 containers will be exposed and available for release during excavation and staging/segregation activities, (5) the contents of not more than 6 containers will be exposed and available for release during sampling and inerting activities, (6) constant visual contact by excavation workers provides quick response to a fire involving depleted uranium, (7) pyrophoric metals fire extinguishment techniques, documented in Fire and Emergency Services General Operating Guideline 3-FES-GOG-229, *Pyrophoric Metals Fire Extinguishment* (Ref. 13), minimize fire propagation, and (8) Fire Department response minimizes fire propagation.

Material-at-Risk

The total radioactive material inventory for T-1 is assumed to be 20,000 kgs of depleted uranium chips/turnings plus a small amount of other radionuclides in the soil (refer to Table 4-1). The total MAR for this accident scenario (in 12 containers), taking credit for segmented excavation, is 10% of 20,000 kgs or 2,000 kgs. The form of material for this postulated accident scenario will be a combination of depleted uranium chips and depleted uranium powder depending on how much uranium metal has been oxidized. If the metal chips or turnings have remained in an oxygen deficient atmosphere in a container or the trench and have experienced little or no oxidation, the material form would more likely be chips. If, on the other hand, the metal chips or turnings have oxidized over time, the material form would more likely be powder. The dose consequence determination conservatively assumes that the material form is 100% chips.

Accident Consequence

The radiological consequences from the postulated fire involving a MAR of 2,000 kgs of depleted uranium chips/turnings are *moderate* (3.3 rem) to the collocated worker and *low* (2.7×10^{-2} rem) to the public. This results in a Risk Class II for the collocated worker and a Risk Class III for the public. The *moderate* consequence to the collocated worker is based on several conservatisms in the dose consequence determination model using the RADIDOSE spreadsheet. These conservatisms and how they affect the dose determination are as follows:

- A conservative atmospheric dispersion factor (χ/Q) associated with 95th percentile weather conditions was used instead of a more representative (or typical) χ/Q associated with Site median (50th percentile) weather conditions - Using a 95th percentile dose concentration determination means that the dose consequences would be smaller 95% of the time and larger only 5% of the time. If median weather were assumed rather than 95th percentile weather, the dose to the collocated worker would be 0.42 rem rather than 3.3 rem, an 87% reduction.
- A plume/release duration (duration of the fire) of 10 minutes was assumed - A pyrophoric metal fire is usually a slow burning smoldering type fire that would have a release duration greater than 10 minutes. In other words, it would take more than 10 minutes to involve the entire postulated MAR of 2,000 kgs. Because the fire would be slow burning, timely response by project personnel and/or the Fire Department would significantly reduce the initial source term, defined as MAR x Damage Ratio (DR) x ARF. If, for example, a 50% reduction in source term could be realized due to timely fire response, a corresponding 50% reduction in radiological dose would also be realized. This would result in reducing the dose to the collocated worker from 3.3 rem to 1.7 rem. If the release duration were assumed to be 30 minutes (which is considered unlikely), the dose to the collocated worker would be reduced from 3.3 rem to 2.7 rem, an 18% reduction.
- The form of material assumed was 100% chips instead of a combination of chips and powder - As depleted uranium chips and turnings oxidize the form of material becomes more powder and less chips. The ARF for chips involved in a fire is 1.0×10^{-2} versus 6.0×10^{-3} for powder involved in a fire. If the material form were assumed to be 50% powder and 50% chips, the dose to the collocated worker would be reduced from 3.3 rem to 1.8 rem, a 45% reduction.
- Unconfined material was used rather than assuming that a portion of the material was at least partially confined in containers (even for partially degraded containers) - The ARF for confined materials is 5.0×10^{-4} versus 1.0×10^{-2} for unconfined chips. If it were assumed that 20% of the MAR is confined material and the remaining 80% unconfined material, the dose to the collocated worker would be reduced from 3.3 rem to 2.7, an 18% reduction.

Based on the conservatisms discussed above, there is high confidence that the actual dose to the collocated worker for this postulated accident scenario is less than 3.3 rem using “reasonable worst-case” assumptions rather than “absolute worst-case” assumptions.

A uranium fire has the potential to cause injury to the immediate worker due to the toxic effects of uranium and is addressed in the site-specific HASP.

Credited Controls

Several controls are credited to prevent or mitigate the postulated accident scenario. Accident prevention controls that reduce the likelihood of a 12 container fire occurring include: (1) segmented excavation techniques that minimize exposure of pyrophoric depleted uranium chips/turnings to air, (2) earthen cover over/around segments not being excavated, and (3) single batch processing (not to exceed six previously buried containers) precluding accumulation of large amounts of unconfined chips/turnings at the SIP area that could be susceptible to a common release mechanism. Accident mitigation controls include: (1) fire suppression techniques for pyrophoric metals, (2) appropriate personal protective equipment to protect the immediate worker, (3) site-specific training that addresses pyrophoric metals fire fighting, and (4) emergency response planning and actions as specified in the site-specific HASP.

4.4.4 Spills

Potential spills can occur within the trench excavation or at the staging/segregation, SIP, or packaged material staging areas. A spill involving depleted uranium chips/turnings is more likely to occur during material handling activities prior to packaging it in approved containers. Once the material is packaged in DOT approved containers, as discussed in Section 2.3, a spill scenario is considered *extremely unlikely* and bounded by a larger spill. Small spills are not further evaluated. The analyzed spill scenario for the T-1 project, summarized in Table 4-6, is postulated to be a spill that releases the contents of 12 previously buried containers (assumed to be 55-gallon drums) during material handling activities. The analyzed spill scenario bounds a release of depleted uranium, in powder form, as a result of crushing or compacting degraded drum carcasses that may contain residual amounts of depleted uranium material because the quantity of material involved would be less than the quantity analyzed.

Table 4-6 Spill Scenario

Hazard	Depleted Uranium Chips/Turnings			
Accident Type	Spill involving the contents of 12 55-Gallon Drums (MAR = 2,000 kgs)			
Cause or Energy Source	Normal excavation techniques that breach drums in order to inspect the contents			
Applicable Activity(ies)	Excavation, Segregation/Staging/Packaging, and Sampling/Inerting.			
Receptor	**Scenario Frequency**	**Consequence**	**Risk Class**	**Credited Controls ***
Public	Unlikely	Low (8.1×10^{-4} rem)	III	The following controls, although not credited as primary accident prevention/mitigation measures, do provide defense-in-depth against this accident scenario occurring: • Segmented excavation (1) • Earthen cover over segments not being excavated (2) • Single batch processing (not to exceed six containers) for sampling and inerting process activities (3) • Site-specific training - safe handling of depleted uranium (9b) • Emergency Response Planning and Actions - HASP (10)
Collocated Worker	Unlikely	Low (1.0×10^{-1} rem)	III	Same as Public
Immediate	Unlikely	Low	III	• Site-Specific HASP - PPE • Emergency Response Planning and Actions - HASP (10)

* The numbers in ( ) refer to controls enumerated in Table 5-1

Scenario Description

The analyzed spill scenario is postulated to involve 12 containers of depleted uranium chips/turnings. This scenario is considered the bounding spill scenario based on the characterization data documented in Section 3, *Site Characterization*. The 12 containers include the number of containers uncovered inside the trench plus the number of containers being managed outside the trench at the staging and segregation area. Excavation of T-1 will be by rows across the width of the trench. A single row is expected to contain between 10 and 12 containers (5-6 55-gallon drums across, stacked two high). A single row will be excavated prior to beginning the next row and a maximum of 12 containers could be potentially exposed at one time. A container breach is postulated to occur as a result of degradation of the container itself or as part of normal activities that include intentionally breaching containers for inspection purposes.

Accident Frequency

A spill involving the entire contents of a few containers (one to three containers) simultaneously is considered *anticipated* since normal project activities will expose the uranium chips/powder. The likelihood of the postulated 12 container spill is judged to be *unlikely* based on the following considerations: (1) visibly degraded containers exposed in the trench will be minimized, (2) intact or partially intact containers exposed in the trench (not to exceed 12) will provide some level of confinement and not expose their entire contents, and (3) the contents of not more than six (6) containers will be exposed and available for release during sampling and inerting activities.

Material-at-Risk

The MAR associated with 12 containers is 2,000 kgs depleted uranium chips/turnings as described in Section 4.4.3 *Material-at-Risk*. It is conservatively estimated that the entire contents of each container is available for release and that 50% of the container contents is in the form of powder. The remaining 50% is considered chips/turnings and is not readily dispersible (ARF = 0 for a spill) if released. Therefore, the DR is 0.50. The effective MAR for this scenario is: 2,000 kgs depleted uranium x 0.50 = 1000 kgs depleted uranium.

Accident Consequence

The radiological consequences from the postulated spill involving a MAR of 2,000 kgs of depleted uranium chips/turnings are *low* (0.1 rem) to the collocated worker and *low* (8.1×10^{-4} rem) to the public using a 95th percentile dose determination. This results in a Risk Class III for both receptors. If this spill scenario involved the entire T-1 radiological inventory of 20,000 kg of depleted uranium chips, assuming that 25% is in the form of powder and 75% is in the form of chips/turnings, the consequence to the collocated worker and the public would still be *low* ($\leq$ 0.5 rem).

A uranium spill has the potential to cause injury to the immediate worker due to the toxic effects of uranium and is addressed in the site-specific HASP.

Credited Controls

Several controls are credited as defense-in-depth against this accident scenario occurring and include: (1) segmented excavation techniques that minimize exposure of depleted uranium chips/turnings, (2) earthen cover over/around segments not being excavated, (3) single batch processing (not to exceed six previously buried containers) precluding accumulation of large amounts of chips/turnings at the SIP area that could be susceptible to a release due to spill, (4) site-specific training that addresses safe handling of depleted uranium, and (5) emergency response planning and actions as specified in the site-specific HASP.

4.4.5 Container Explosion

Excavated and intact containers of depleted uranium chips/turnings may contain sufficient amounts of hydrogen (due to radiolysis over a 40 year period) and oxygen that, if ignited, could result in an explosion. Additionally, depleted uranium inerted with mineral oil and packaged in 83-gallon overpack containers could potentially generate hydrogen gas due to radiolysis during storage at the packaged material storage area. Hydrogen gas buildup is precluded in this situation by (1) the internal contents vented to the overpack container, (2) vented overpack containers, and (3) the short period of time the packaged material will be stored on-site awaiting off-site shipment. A vented container control is specified in Table 5-1, *Project Hazard Controls.*

The analyzed explosion scenario for the T-1 project, summarized in Table 4-7, is postulated to be a single container (assumed to be a 55-gallon drum) explosion occurring in the excavation.

Table 4-7 Explosion Scenario

Hazard	Depleted Uranium Chips/Turnings			
Accident Type	Explosion involving a single 55-Gallon Drum of DU (MAR = 165 kgs)			
Cause or Energy Source	Hydrogen and oxygen radiolytically generated in a 55-gallon drum, filled with depleted uranium chips/turnings and water-soluble lathe coolant, is ignited by a spark created during drum puncture.			
Applicable Activity(ies)	Excavation			
Receptor	**Scenario Frequency**	**Consequence**	**Risk Class**	**Credited Controls ***
Public	Unlikely	Low (4.4×10^{-5} rem)	III	• Spark-proof excavator bucket (4) • Spark-proof punch (5)
Collocated Worker	Unlikely	Low (5.5×10^{-3} rem)	III	Same as Public
Immediate	Unlikely	Low	III	• Site-Specific Training - use of proper PPE by equipment operators at the trench (9) • Emergency Response Planning and Actions - HASP (10)

* The numbers in ( ) refer to controls enumerated in Table 5-1

Scenario Description

It is postulated that hydrogen gas is radiolytically generated in a container that has remained sealed for 40 years and contains depleted uranium chips/turnings coated with a water-soluble lathe coolant. It is assumed that the water in the lathe coolant generates enough oxygen to combust the hydrogen that is generated by radiolysis (this condition requires there be at least

10 times as much water present as oil because of the differences in the amount of hydrogen released from oil versus water). Ignition occurs due to a small spark created when the drum is punctured by earth moving equipment during excavation activities (Ref. 25).

A hydrogen explosion initiated by a small energy source in a confined space, such as a 55-gallon drum, would be a deflagration, and would not have the opportunity to transition to a detonation, which would have peak pressures normally twice those developed in a deflagration. A deflagration behaves like a rapid burn and does not develop a supersonic shock wave at the flame front, as occurs in a detonation. The flame front in a deflagration propagates at subsonic velocities, and the pressure rise in the drum equilibrates at acoustic speeds. It is assumed that the pressure rise within the container is sufficient to separate the lid from the container and release a fraction of the container contents. Tests described in Ref. 26 demonstrate that if ignition of drum free volume gases containing greater than 15% hydrogen and 7.5% oxygen, by volume, occurs, the lid will separate from the drum.

Accident Frequency

The frequency of a container explosion due to hydrogen ignition is judged to be *unlikely* based on the following considerations: (1) the unlikely probability that a steel container has remained intact and sealed for 40 years allowing accumulation of hydrogen gas, (2) the assumption that containers containing depleted uranium chips/turnings have undergone radiolysis over time resulting in sufficient amounts of hydrogen gas and oxygen to create an explosive atmosphere within a container, (3) the unlikely presence of an ignition source within a sealed container that contains hydrogen gas, (4) the use of a non-sparking excavator bucket that reduces spark producing potential (ignition source), and (5) the use of a non-sparking punch to pierce container lids.

Material-at-Risk

The postulated scenario involves the release of contamination due to ignition of hydrogen/oxygen constituents contained in the headspace of a single container. Since this event is not envisioned to involve neighboring containers, the average material at risk is the contents of one container.

Not all of the MAR in a container would be impacted by the explosion. Arguments put forth in the supporting calculation (Ref. 5) justify that it is conservative to apply DR of 0.1 to the drum. Assuming that a container with 165 kg (~364 pounds) of depleted uranium is involved in the explosion, the effective MAR = 165 kgs depleted uranium x 0.1 DR = 16.5 kgs depleted uranium.

Accident Consequence

The radiological consequences from the postulated single drum explosion are *low* (5.5×10^{-3} rem) to the collocated worker and *low* (4.4×10^{-5} rem) to the public using a 95th percentile dose determination.

For the immediate worker the radiological consequence is judged to be *low*. However, a single container explosion has the potential to cause injury to the immediate worker due to explosion overpressure and blast effects and inhalation of depleted uranium. The TNT equivalent of the postulated explosion is 34 grams (about 1.2 ounces) which is not enough energy to create shrapnel from the container (unless the container was significantly weakened by corrosion over time, in which case the container would probably not be well enough sealed to preclude hydrogen leakage) and would not propel the container contents with sufficient force to seriously injure a machinery operator located in the immediate vicinity of the explosion. For these reasons a *low* consequence has been assigned to the immediate worker due to explosion effects. Project procedures preclude the presence of workers in the excavation area (trench) during container removal (excavation) which is when an explosion is most likely to occur. Personal protective equipment prescribed for the worker operating the earth moving equipment is addressed in the site-specific HASP (Ref. 1).

Credited Controls

Controls that provide defense-in-depth protection to the public and the collocated worker by reducing the accident scenario frequency include (1) the use of a non-sparking excavator bucket for material handling, and (2) the use of a non-sparking punch to pierce drum lids. These same controls are directly credited to protect the immediate worker from explosion blast effects. Additionally, the immediate worker is protected from explosion blast effects by the use of prescribed personal protective equipment.

4.4.6 Nuclear Criticality

The Nuclear Criticality Safety Manual (Ref. 27) identifies fissionable materials that shall be controlled under the criticality safety program at RFETS. Depleted uranium in any amount (except as reflectors) is exempt from subcontractor criticality safety control. For this reason, no plausible criticality scenarios have been postulated and evaluated.

4.4.7 Transportation Accidents

A transportation accident involving depleted uranium can only occur subsequent to the material being packaged in DOT Specification 7A packaging appropriate for pyrophoric Class 7 (radioactive) materials and loaded on a closed van transportation vehicle. RMRS will assure that testing and certification data are provided to document that all packaging meets DOT criteria. RMRS will also assure that the maximum activity of depleted uranium permitted to be packaged in a single Type 7A container is not exceeded.

Nuclear Safety Technical Report, NSTR-015-97, *Salt Stabilization Program Transportation Risk* (Ref. 28) concludes that the accident scenario frequency is *incredible* (less than 1×10^{-6} events/year) for the following on-site transportation accidents: (1) truck accident resulting in medium spill, (2) truck accident resulting in major spill, (3) truck accident resulting in fire, and (4) vehicle fire spreads and involves containers. The scenario frequency determinations for these accidents take into consideration miles traveled (for truck accidents) and cargo residence time on the vehicle (for vehicle fire) that are greater than those that would be experienced during the on-site transportation of depleted uranium. Therefore, the frequencies of these events would be less for the T-1 Project transportation activities than for the Salt Stabilization Program.

Credible on-site transportation accidents identified in NSTR-015-97 include: (1) truck accident with no release, (2) truck accident resulting in a minor spill, (3) drum ruptures due to hydrogen buildup/ignition, and (4) movement disturbs reactive or pyrophoric material resulting in fire. Of these four credible scenarios, only a truck fire resulting in a minor spill is of concern during the on-site transportation of depleted uranium. A transportation accident resulting in a minor spill is considered *extremely unlikely* and is assumed to be bounded by the spill scenario summarized in Table 4-6.

Based on the results of NSTR-015-97 and the fact that Type A quantities of depleted uranium will be packaged in Type A containers suitable for over-the-road shipment, no further evaluation of transportation accidents is warranted for the T-1 Source Removal Project.

5. HAZARD CONTROLS

Controls that protect the collocated worker and/or the public from radiological hazards associated with the T-1 Source Removal Project are identified in Table 5-1. These controls are credited as preventing occurrence of the postulated accident scenarios and mitigating the consequences if an accident were to occur. In addition, controls associated with an "investigate and correct" work approach are included in Table 5-1. The "investigate and correct" controls will be relied upon for characterizing anticipated hazards as well as identifying unforeseen and/or uncharacterized hazards that represent an unknown threat. Unforeseen and/or uncharacterized hazards will be managed in accordance with RMRS Operations Directive OPS-DIR-001, *Safety and Environmental Stewardship Directive* (Ref. 29) that states:

> "It is the intent of RMRS to adequately address unexpected hazards or conditions encountered during environmental restoration, waste management, and decontamination and decommissioning activities. In the event that unanticipated hazards or conditions are encountered, the project activities will pause to assess the potential hazard or condition. The potential hazard or condition will be evaluated to determine the severity or significance of the hazard or condition and whether the existing project controls are sufficient to address the hazard or conditions. Based on this initial evaluation, a determination will be made whether to proceed with controls currently in place, segregate the condition or hazard from the project activity, if this can be done safely; or curtail operations to address the unexpected hazard or condition. Concurrence to proceed down the selected path must be obtained from the respective RMRS Director or their designee."

Unanalyzed hazards and conditions or any modification to project activities or work that fall outside the bounds of this safety analysis shall be assessed through the USQD process. Modifications to project activities or work could result from a change in project scope or discovery of unanticipated hazards or conditions. The USQD process assures that modified or additional project activities or work, not previously analyzed, can be safely performed with the existing set of controls; or that additional controls have been identified, verified to be those

Table 5-1 T-1 Project Hazard Controls

Control	Control Type	Implementation Method
Preventive and Mitigative Controls Credited in Section 4, *Accident Analysis*		
1. Excavation and staging/segregation activities will not expose more than the contents of 12 previously buried containers of depleted uranium chips/ turnings (~2,000 kgs. of DU at one time).	Physical Separation/Work Limitation	Project plan and procedures
2. Earthen cover over/around trench segments not being excavated.	Passive Barrier	Project plan and procedures
3. Sampling and inerting activities will not expose more than the contents of 6 previously buried containers of depleted uranium (~1,000 kgs. of DU).	Work Limitation	Project plan and procedures
4. Non-sparking excavator bucket.	Equipment Design Feature	Project plan and procedures
5. Non-sparking punch.	Equipment Design Feature	Project plan and procedures
6. Vented containers.	Equipment Design Feature	Operations Order for Material Packaging
7. Fire suppression techniques for pyrophoric metals and mineral oil.	Stabilizing Condition	Site-Specific HASP
8. Verification that depleted uranium is not undergoing a thermal reaction when inerting with mineral oil.	Stabilizing Condition	Site-Specific HASP and Operations Order for Material Packaging
9. Site-specific training: a) Pyrophoric metals fire fighting b) Safe handling of depleted uranium	Stabilizing Condition	Site-Specific HASP
10. T-1 Site Emergency Response Planning and Actions.	Stabilizing Condition, Work Limitation, Hold Points	Site-Specific HASP
11. Storage of waste materials at the T-1 Site: a) Placement of barriers to maintain a 1.5 meter (5 feet) clear area around the material storage area. b) Control ignition sources within the material storage area.	 Physical Separation Work Limitation	 Project plan and procedures Project plan and procedures
"Investigate and Correct" Controls		
12. Nuclear Safety accident analysis thresholds: 1 gram total Pu (WG Pu)/packaged container 3,960 grams ^{235}U (eU)/packaged container	Hold Point	Site-Specific HASP
13. Criticality Safety fissile material thresholds: 100 nCi/g Pu concentration 15 grams fissile uranium/ packaged container	Hold Point	Criticality Safety Program Implementation Plan for Trench 1 (Ref. 32) and Site-Specific HASP
14. Radiological surveys.	Hold Point	Site-Specific HASP and ALARA job review
15. Radiological and chemical emissions monitoring.	Field Investigation	Site-Specific HASP and ALARA job review

necessary and sufficient to conduct the planned activities or work, and have been documented and implemented.

Additionally, RMRS Operations Directive OPS-DIR-002, *Authorization Basis,* (Ref. 30), requires a revised or new authorization basis if project operational controls are not sufficient to adequately address unanticipated hazards or conditions that are encountered. The project or technical manager is responsible for recognizing these unanalyzed situations and requesting the necessary evaluation and revision to the applicable authorization basis (the site-specific HASP and this safety analysis) in order to proceed with the work in a safe and compliant manner.

T-1 project hazard controls include (1) physical separation, (2) passive barriers, (3) work limitations, (4) stabilizing conditions, (5) equipment design features, (6) hold points, and (7) field investigation techniques. Physical separation is the primary method that is used for establishing facility segments. Passive barriers prevent the interaction of hazardous materials for the purpose of defining facility segments. A passive barrier is defined as a feature whose physical configuration and/or other physical characteristics furnish the safety function of the barrier. For the T-1 excavation, an earthen cover is considered a passive barrier. Work limitations are restrictions that limit the magnitude of risk due to investigative and retrieval activities (excavating, staging, and inerting) by only allowing interaction with a fraction of the hazardous material present. Stabilizing conditions are the engineered features or administrative controls that will minimize releases during work, non-work hours, work interruptions, and completion of discovery scope of activity. Equipment design features are equipment characteristics that are relied upon to provide some degree of risk reduction. For T-1 Source Removal Project activities, credited equipment design features include non-sparking equipment that reduces the likelihood of a container explosion. Hold points provide administrative controls on the amount of hazardous material retrieved before characterization and control. Hold points also identify the "degree" of field characterization and communication needed to remove the material from the immediate work area. Examples of hold points are Controls 9 and 10 in Table 5-1. These controls address the radiological material thresholds that, if exceeded, require additional characterization, evaluation, and control from a nuclear and/or criticality safety analysis perspective. Field investigation techniques assist in identifying anticipated hazards as well as unforeseen/ uncharacterized hazards.

Controls that protect the immediate worker from radiological, chemical, biological, and physical hazards associated with the T-1 Source Removal Project are prescribed in the site-specific HASP (Ref. 1) and are not addressed here.

<u>Hazard Control Bases:</u>

1. This control requirement limits the quantity of depleted uranium that can be exposed during T-1 excavation activities and potentially involved in a fire or spill resulting in an airborne release. The control limits the quantity of material exposed to the contents of 12 previously buried containers (assumed to be 55-gallon drums) or approximately 2,000 kgs of depleted uranium (approximately 165 kgs of depleted uranium per drum). This 12 container limit includes the number of containers uncovered inside the trench <u>plus</u> the number of containers being managed outside the trench at the adjacent staging and segregation area. The contents of 12 55-gallon drums equates to roughly 88 ft^3 or 3.3 yd^3 of material. Limiting the quantity of material exposed assures that off-site radiological consequences to the public (Maximum Off-site Individual, MOI) would be negligible in the event that the postulated fire or spill accident scenarios were to occur.

The radiological consequence to the public from an accidental airborne release of radioactive material is negligible for a facility/site that contains less than Nuclear Facility Hazard Category 3 threshold quantities (allowing segmentation). The depleted uranium (^{238}U) threshold that results in a Nuclear Hazard Category 3 classification is 13,000 kgs of releasable material. By implementing this approximate 2,000 kg limit, adequate margin of safety is provided so that the T-1 site can be confidently classified as radiological. This margin of safety accounts for uncertainty that may exist regarding the exact quantity of depleted uranium being uncovered during excavation. Compliance with this 2,000 kg limit should be based on project personnel judgment of how much material has actually been uncovered at any one time. Some uncertainty will exist since it is anticipated that a portion of the buried containers have degraded over time and some of the depleted uranium will be commingled with the soil matrix. This uncertainty will require that personnel "estimate" the amount of material uncovered in order to comply with this limit. The margin of safety provided by this limit allows some degree of error when making the estimation.

2. By maintaining a layer of earthen cover over all unexcavated portions of the trench, the material beneath the soil layer will not be available for potential release. This control along with control #1 are credited as preserving site segregation. Site segregation assures (1) the quantity of depleted uranium exposed at any one time remains below the Nuclear Hazard Category 3 threshold of 13,000 kgs, and (2) the T-1 site can be classified as a radiological site.

3. This control requirement limits the quantity of depleted uranium that can be exposed during T-1 inerting activities and potentially involved in a fire or spill resulting in an airborne release. The control is applicable at the SIP. The control limits the quantity of material exposed to the contents of 6 previously buried containers (assumed to be 55-gallon drums) or approximately 1,000 kgs of depleted uranium (assuming 165 kgs of depleted uranium per drum). The contents of 6 55-gallon drums equates to 44 ft^3 or 1.6 yd^3 of material. Limiting the quantity of material exposed assures that the off-site radiological consequences to the public (MOI) would be negligible in the event that the depleted uranium were involved in a fire or spill. This 6 container control limit ensures (1) that a fire or spill at the SIP is bounded by the postulated fire and spill scenarios analyzed in Section 4.4, and (2) that the T-1 site can be classified as radiological.

4. The use of a non-sparking excavator bucket is credited to reduce the frequency of the postulated explosion scenario. Containers of depleted uranium with an explosive mixture of hydrogen and oxygen, due to radiolysis, may potentially explode if an ignition source (such as a spark) is provided. The heavy equipment excavator bucket will be contacting the steel waste containers as they are being uncovered and removed from the trench. In some cases the bucket may be used to breach a pressurized container, releasing the hydrogen, prior to removing the container from the trench. The use of a non-sparking excavator bucket reduces the spark producing potential and reduces the probability of a fire and/or explosion in the trench.

5. The use of a non-sparking punch is credited to reduce the frequency of the postulated explosion scenario. Containers of depleted uranium with an explosive mixture of hydrogen and oxygen, due to radiolysis, may potentially explode if an ignition source (such as a spark) is

provided. A punch, used in conjunction with the heavy equipment excavator bucket, will be used to breach a pressurized container, releasing the hydrogen, prior to removing the container from the trench. The use of a non-sparking punch reduces the spark producing potential and reduces the probability of a fire and/or explosion in the trench.

6. The 83-gallon overpack containers that will be used to inert and package the potentially pyrophoric depleted uranium shall contain vents. Vented containers preclude the buildup of hydrogen gas that may be generated due to radiolysis while the containers are stored at the packaged material storage area awaiting off-site shipment. Health and Safety Practice (HSP) 31.12, *Transfer and Storage of Pyrophoric Metals other than Plutonium for Fire Safety*, requires that storage containers be vented to eliminate pressurization (Ref. 31). If it becomes necessary to store the inerted depleted uranium on-site rather then ship it off-site for treatment, additional safety analysis may be required to address hydrogen gas generation.

7. The use of approved fire extinguishment techniques for fires involving pyrophoric metals and/or mineral oil provides mitigation in the event that a fire occurs at the excavation, staging/segregation area, or the SIP. Any response, either by the Fire Department or project personnel, that reduces the fire duration time would effectively reduce the amount of material consumed in the fire. The amount of material released to the atmosphere would therefore be minimized and a subsequent reduction in the accident consequences would be realized. Pyrophoric metals fire extinguishment guidelines are contained in Fire and Emergency Services General Operating Guideline 3-FES-GOG-229, *Pyrophoric Metals Fire Extinguishment* (Ref. 13). The Fire Department shall also be provided a copy of the Material Safety Data Sheet (MSDS) for mineral oil that includes fire hazard data.

8. Verification that pyrophoric depleted uranium is not undergoing a thermal reaction when mineral oil is added prevents the ignition and subsequent burning of the mineral oil. Verification methods may include visual inspections and the use of temperature sensing devices.

9. T-1 site-specific training of project personnel on pyrophoric metals fire fighting techniques helps mitigate the consequences of a depleted uranium fire. If a fire were to occur involving depleted uranium, timely response to control or extinguish the fire minimizes the release duration and the quantity of material involved in the fire. Personnel shall be adequately trained on how to properly use extinguishing agents such as sodium chloride based powders (i.e., MET-L-X) and dry magnesium oxide powders as applicable. In the event that personnel cannot respond, for whatever reason, they shall be trained on site-specific notification and reporting requirements so that timely response by the Fire Department can be provided.

   Training on the safe handling of depleted uranium is credited to minimize the quantity of depleted uranium released to the atmosphere. Training shall cover the safe transfer and storage of pyrophoric materials as addressed in applicable operations orders and HSP 31.12 (Ref. 31).

10. Potential emergency situations during work at the T-1 site include but are not limited to hazardous substance releases (radiological and chemical), employee contamination, accidents, injuries, fire, and natural disasters. This control is credited in each of the postulated accident

scenarios (fire, spill, and explosion) as mitigating the consequences to the public, the collocated worker, and the immediate worker. In the event that an emergency situation arises, emergency procedures should include evacuation procedures, emergency contacts and phone numbers, hazardous substance release response, employee contamination response, accident/injury response, and identification of emergency equipment.

11. Controls applicable to the material storage area are credited to reduce the frequency and/or mitigate the consequences of uncontrolled releases of radioactive or other hazardous materials in the event of a fire at the site. These controls help to protect the health and safety of the public, collocated workers, and immediate workers.

    Providing a barrier (*e.g.*, jersey barriers) around the material storage area precludes fossil-fueled vehicles from coming in close proximity to the area and minimizes the consequences of a fuel spill and ensuing pool fire. Since the material storage area has a soil surface, the pooling fuel would begin to penetrate into the ground and would spread toward the waste containers at a slower rate than if the surface were concrete or asphalt. In the event that the pooling fuel is ignited, the separation distance will minimize the number of waste containers initially impacted. A barrier around the material storage area also prevents propagation of a fire involving transient combustibles. Per Fire Protection Engineering, a 5-foot distance is adequate to prevent a two wooden waste crate fire from breaching a 55-gallon metal drum. In other words, a fire involving two wooden waste crates burning at a distance of 5 feet from a 55-gallon drum would not subject the drum to the critical failure heat flux of $45 kW/m^2$ (the heat flux necessary to cause drum venting).

    Control of ignition sources such as hot work and smoking reduces the probability of a fire occurring within the material storage area.

12. This control establishes the amounts of total Pu (WG Pu) and ^{235}U (eU) that can be excavated and packaged in Type 7A containers before additional characterization, evaluation, and control must be considered from a nuclear safety accident analysis perspective. The threshold quantities apply to a single packaged container regardless of its volume.

    The per container threshold quantities are based on a credible bounding fire accident scenario involving two Type 7A containers. A two container fire bounds a two container spill because the product of the ARF and the respirable fraction (RF) is less for a spill (0.0006) than for the fire scenario (0.01) and therefore the radiological dose consequences are lower.

    The fire is postulated to occur in combustibles in proximity to the Type 7A containers due to administrative control failures allowing combustibles to accumulate and to be placed near the containers. A fire involving just two containers is considered a bounding accident scenario based on the following considerations (1) the material will be packaged in Type 7A metal containers with low container-to-container heat transmission and subsequent limited fire propagation potential, (2) the absence of combustibles, and (3) the absence of potential ignition sources. Based on scenario assumptions, the gram/container limits assure that the radiological consequences are *low* (≤ 0.1 rem) to the public and *low* (≤ 0.5 rem) to the collocated worker. The determination of the Nuclear Safety accident analysis thresholds is detailed in the Trench T-1 Safety Analysis Support Calculation (Ref. 5).

If the threshold for total Pu or ^{235}U (eU) is exceeded, the project shall establish a hold point and the RMRS Authorization Basis organization shall be notified. Evaluation of hazards involving material quantities exceeding the thresholds established by this safety analysis has not been performed. Unanalyzed hazards or conditions shall be assessed through the USQD process prior to resuming project activities.

13. This control establishes the amount of fissile material that can be retrieved before additional characterization, evaluation, and control must be considered from a criticality safety analysis perspective. The threshold quantities apply to a single packaged container regardless of its volume. Should material in excess of the stated limits for total Pu or fissile uranium be discovered, the project shall establish a hold point and the RMRS Criticality Safety Officer and/or Criticality Safety Engineer shall be notified. The Criticality Safety Officer and/or Criticality Safety Engineer will provide further guidance on implementing appropriate criticality safety controls prior to resuming project activities. A criticality safety evaluation may be required. Reference the Criticality Safety Program Implementation Plan for Trench 1 (Ref. 32) for additional information regarding T-1 criticality safety.

14. Radiological surveys provide worker safety and protect the collocated worker and the public from unforeseen/uncharacterized hazards.

15. Radiological and chemical emissions monitoring provides worker safety and protects the collocated worker and the public from unforeseen/uncharacterized hazards.

6. REFERENCES

1 *Site Specific Health and Safety Plan for the Source Removal at the T-1 Site IHSS 108*, **RF/RMRS-97-010**, Rocky Mountain Remediation Services LLC, March 1998.

2 *Final Proposed Action Memorandum (PAM) for the Source Removal at Trench 1, IHSS 108*, **RF/RMRS-97-011**, Revision 3, Rocky Mountain Remediation Services LLC, May 1997.

3 *Hazard Baseline Documentation*, **DOE Environmental Management Standard 5502-94**, U. S. Department of Energy, Washington D. C., August 1994.

4 *Hazardous Waste Operations and Emergency Response*, **Code of Federal Regulations, 29 CFR 1926.65**, Department of Labor, Occupational Safety and Health Administration, Washington D. C.

5 *Support Calculation - Safety Analysis for Individual Hazardous Substance Site (IHSS) 108 Trench 1 (T-1) Source Removal Project*, Calculation **97-SAE-010**, Nuclear Engineering, Rocky Flats Environmental Technology Site, January, 1998.

6 *Final Rocky Flats Cleanup Agreement*, Rocky Flats Environmental Technology Site, Golden, CO.

7 *Nuclear Safety Analysis Reports*, **DOE Order 5480.23**, U. S. Department of Energy, Washington D. C., April 30, 1992.

8 *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports*, **DOE Standard 1027-92**, U. S. Department of Energy, Washington D. C., December 1992.

9 *Designation, Reportable Quantities, and Notification*, **Code of Federal Regulations, 40 CFR 302**, Environmental Protection Agency, Washington D. C.

10 *Process Safety Management*, **Code of Federal Regulations, 29 CFR 1910.119**, Department of Labor, Occupational Safety and Health Administration, Washington D. C.

11 *Risk Management Programs (RMP) for Chemical Accidental Release Prevention*, **Code of Federal Regulations, 40 CFR 68**, Environmental Protection Agency, Washington D. C.

12 *Emergency Planning and Notification*, **Code of Federal Regulations, 40 CFR 355**, Environmental Protection Agency, Washington D. C

13 *Pyrophoric Metals Fire Extinguishment*, **3-FES-GOG-229**, Fire and Emergency Services General Operating Guidelines, April 23, 1996.

14 *Proposed Action Memorandum for the Source Removal at the Mound Site, IHSS 113*, **RF/RMRS-96-0059**, Rocky Mountain Remediation Services LLC, December 16, 1996.

15 *Authorized Packages-Pyrophoric Class 7 (Radioactive) Materials*, **Code of Federal Regulations, 49 CFR Part 173.418**, Department of Transportation, Washington D. C.

16 *Placement of Investigative Derived Material (IDM) into Trench 1*, **SES-TR1-99.0086-JSK**, November 19, 1998.

17 *Rocky Flats Environmental Technology Site Radiological Controls Manual*, Kaiser-Hill, Inc., 1996.

18 ALARA Job Review, *Gamma Spectroscopy of Trench One Samples in Trailer T-900C*, Log No. 98-881-001.

19 *Guidance for Preparation of DOE 5480.22 (TSR) and DOE 5480.23 (SAR) Implementation Plans*, **DOE Standard 3011-94**, U. S. Department of Energy, Washington D. C., November 1994.

20 *Preparation Guide for U. S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports*, **DOE Standard 3009-94**, U. S. Department of Energy, Washington D. C., July 1994.

21 *Tools and Methodology for Collocated-Worker Consequence Assessments*, **RFP-4911**, Revision 0, Rocky Flats Environmental Technology Site, Golden, CO, October 31, 1994.

22 *Safety Analysis and Risk Assessment Handbook,* **RFP-5098 (also, NSTR-007-96)**, Authorization Basis/ Program Compliance, Rocky Flats Environmental Technology Site, Golden, CO, April 22, 1997.

23 *Radiological Dose Template*, Calculation **96-SAE-034**, Safety Analysis / Nuclear Engineering, Rocky Flats Environmental Technology Site, Golden, CO, March 12, 1997.

24 *Fire Protection Handbook,* Eighteenth Edition, National Fire Protection Association, Quincy, MA., 1997.

25 *Trench 1 Hydrogen Explosion Accident Analysis*, **DPS-131-97**, Kaiser-Hill Letter from D. P. Snyder to D. R. Swanson, dated August 20, 1997.

26 *TRU Drum Hydrogen Explosion Tests,* **WSMC-TR-90-165**, Westinghouse Savannah River Company, Dykes, K. L. and Neyer, M. L.

27 *Nuclear Criticality Safety Manual,* Revision 0, Rocky Flats Environmental Technology Site, March 1, 1996.

28 *Salt Stabilization Program Transportation Risk*, Nuclear Safety Technical Report, **NSTR-015-97**, Safe Sites of Colorado LLC, Golden, Colorado, October 15, 1997.

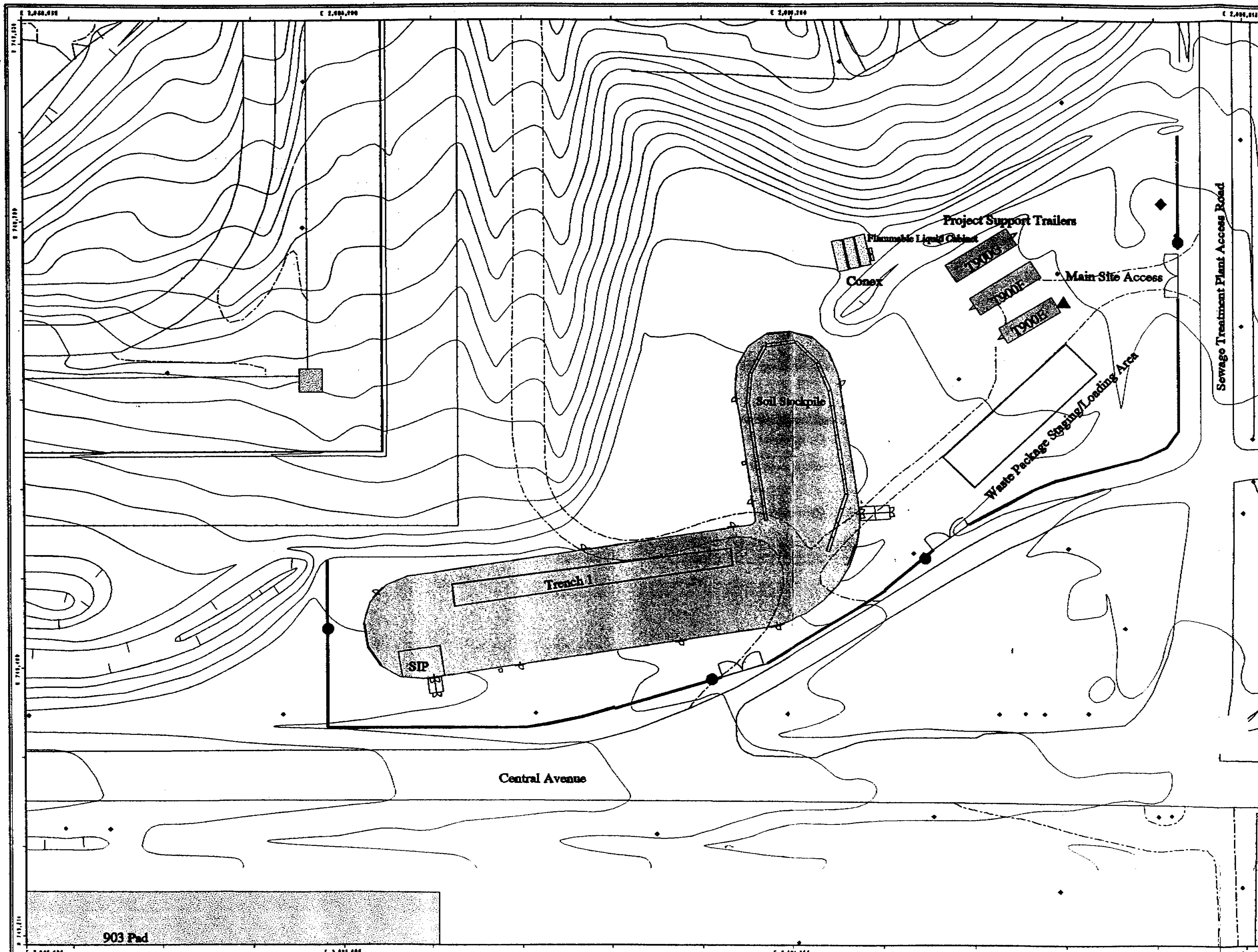
29 *Safety and Environmental Stewardship Directive*, **OPS-DIR-001**, Rocky Mountain Remediation Services LLC, Golden, Colorado, August 15, 1997.

30 *Authorization Basis*, **OPS-DIR-002**, Rocky Mountain Remediation Services LLC, Golden, Colorado, July 10, 1997.

31 *Transfer and Storage of Pyrophoric Metals other than Plutonium for Fire Safety*, **1-X46-HSP-31.12**, Rocky Flats Environmental Technology, Fire Protection Engineering, May 30, 1997.

32 *Criticality Safety Program Implementation Plan for Trench 1*, **RF/RMRS-98-217**, Rocky Mountain Remediation Services LLC, Golden, Colorado, February, 1998.

Trench 1
Site Layout
Figure 1 -1



EXPLANATION

- Personnel Access Gate
- Personnel Accountability Tag Board
- Primary Assembly Area
- 2 Foot Contours
- Safety Fence
- Trench 1 Boundary
- Temporary Structure Boundary

SIP = Sampling and Inerting Pad

Standard Map Features

- Buildings and other structures
- Fences and other barriers
- Paved roads
- Dirt roads

DATA SOURCE: Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the othophotographs. 1/95

Scale = 1 : 800
1 inch represents approximately 67 feet

25 0 50 100ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:

RMRS Rocky Mountain Remediation Services, L.L.C.

MAP ID: 98-0115

May 11, 1998